Vol. 13, No. 6 June, 1957

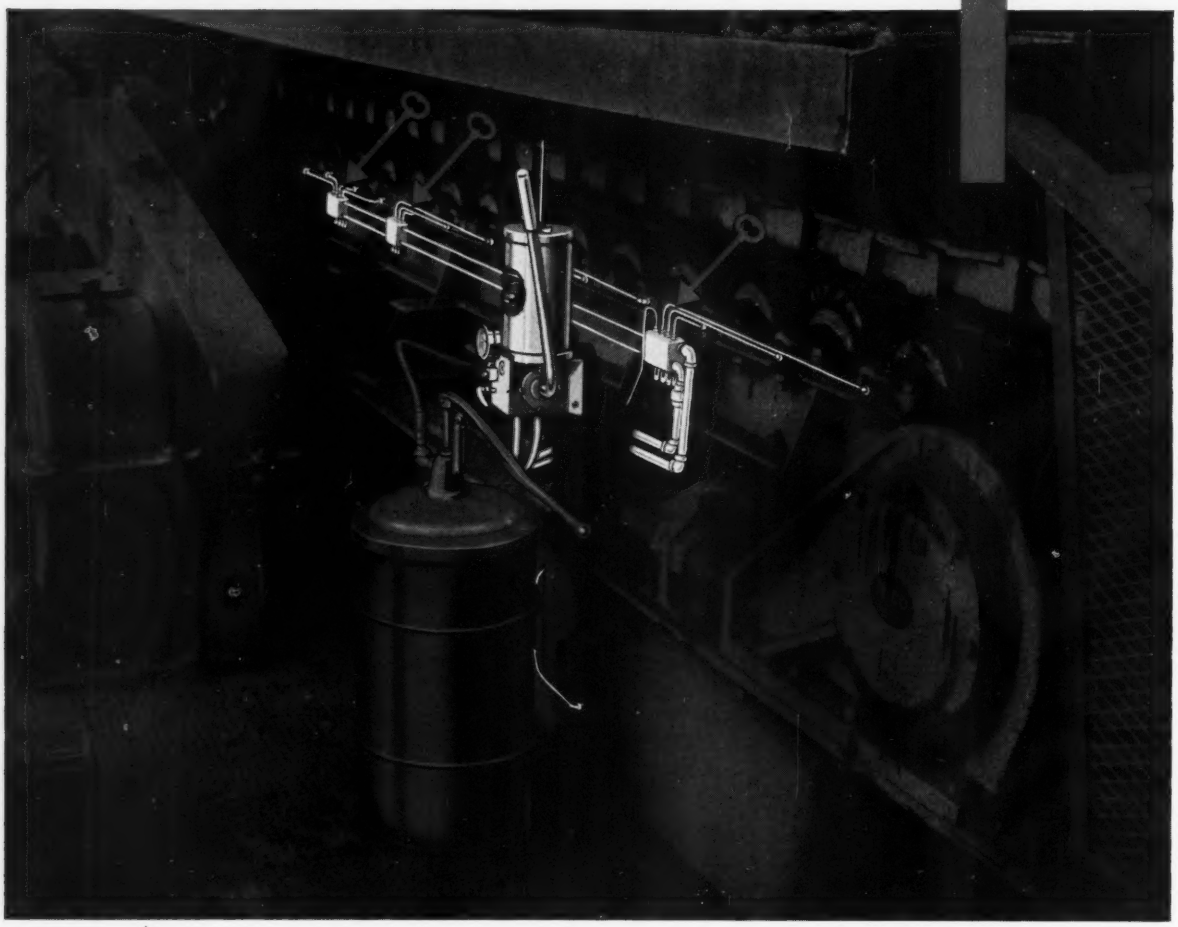
LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Farval keeps pan feeders running smoothly in dust and grime of ore processing plant

FARVAL—
Studies in Centralized Lubrication
No. 201



KEYS TO ADEQUATE LUBRICATION—
Wherever you see the signs of Farval—the familiar central pumping station, dual lubricant lines and valve manifolds—you know a machine is being properly lubricated. Farval-lubricated heavy-duty manganese feeder, at work in Hanna's new Hunner plant at Coleraine, Minn., is made by National Iron Co., Duluth.

● No matter how dusty the air and thick the grime, the Farval-protected bearings on this feeder will run bright, unworn and clean for years to come. Serving 37 points of lubrication, this manually operated system is one of five installed recently on pan feeders for ore processing plants in the Iron Range of Minnesota.

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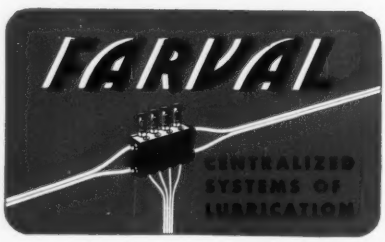
There are thousands of Farval automatic and manually operated systems in use, serving millions of industrial bearings. Millions more *need* Farval. If you have a machine that could benefit from better lubrication, write for our Bulletin 26-S. The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



LUBRICATION ENGINEERING

RESEARCH APPLICATION EDUCATION MAINTENANCE

Volume 13, No. 6

June, 1957

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LUBRICATION ENGINEERING is published monthly by the American Society of Lubrication Engineers, 84 E. Randolph St., Chicago 1, Illinois. Current volume single copies 75c. Copies of issues from previous volumes $1.00, if available; Copies to Foreign addresses add 50c per copy. Annual Subscription $6.00 in the USA and Canada, $7.00 to all other countries.

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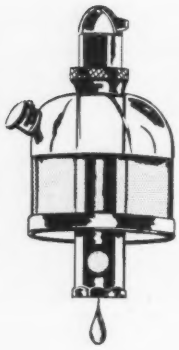
The Sight Glass



Highlights of Articles Scheduled for Coming Issues!

Lubrication in a Chemical Plant

Although the volume of lubricants used by plants in the chemical industry is relatively small, correct use of the right product is essential to continuous operation of equipment. Charts show the organization of a plant engineering group for an integrated product producer and for the diversified plant. Types of fluid lubricants used are listed as percent of usage, as are types of greases. Stores reduction, lubricant cost savings, and numbers of lubricants used before and after establishing a lubrication program emphasize savings available through effective lubrication engineering.

Industrial Dermatosis Symposium — Questions & Answers

The final article of the current series treating the Industrial Dermatosis will be a panel session of questions and answers. Some of the topics include: Adding Disinfectants to Cutting Oils; Effects of Breathing Soluble and Insoluble Cutting Oils; Recommendations on Protective Ointments for the Employee; Opinions on the Relative Skin Toxemia of Glycol-Water Base, Organic Phosphate, and Diester Lubricants; and liability of the employer for continued recurrence of dermatitis.

Some Effects of Gamma Radiation on Commercial Lubricants

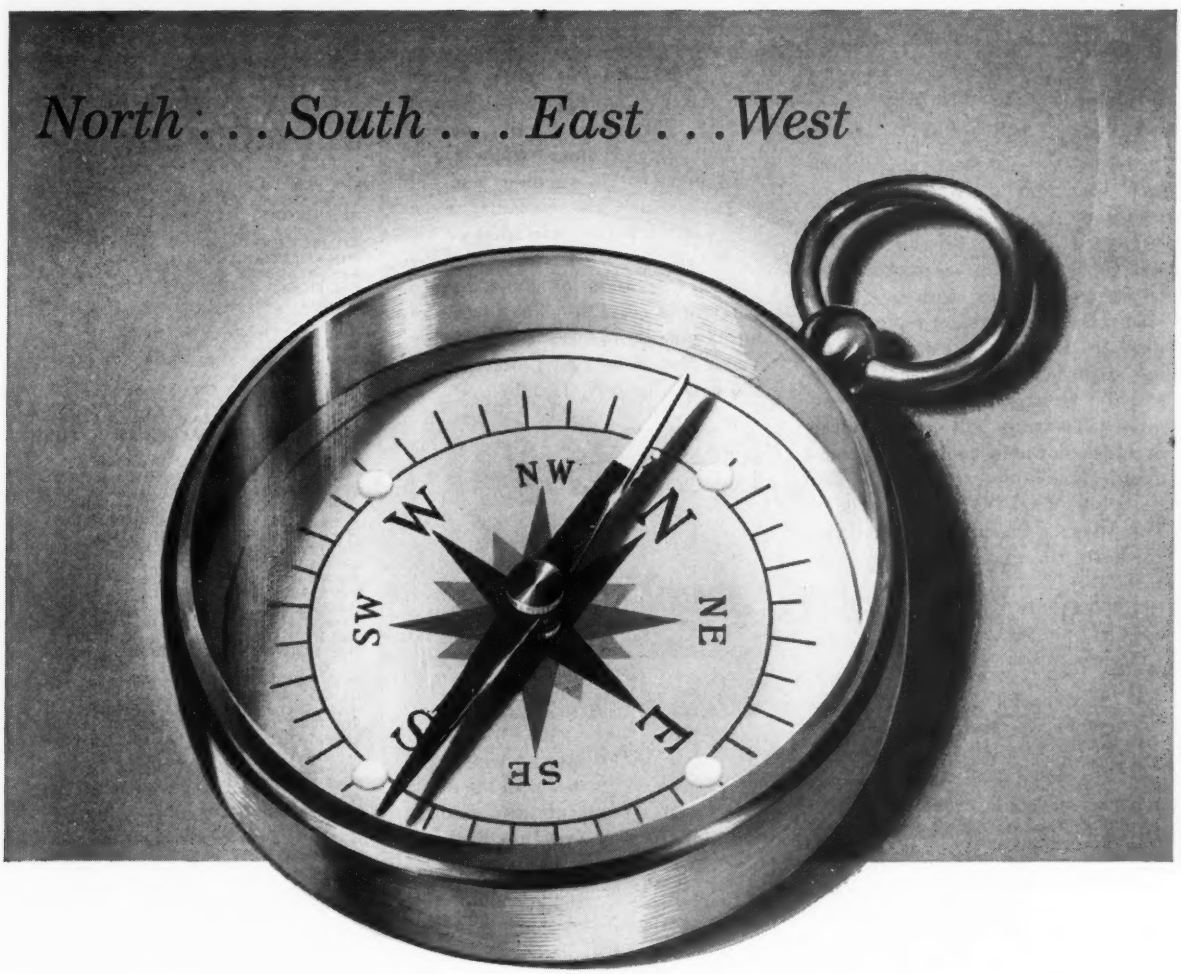
Twenty-eight lubricants; including four base oils, four industrial oils, two gear lubricants, an automatic transmission fluid, three industrial greases, and three multipurpose greases were exposed to gamma rays. Tests involving exposures ranging from 10^5 to 9×10^8 roentgens at about 80° F show that the effects of radiation on compounding in lubricant are probably more limiting than the effects on the base oil. Some commercial lubricants are useful for gamma dosage of at least 10^8 roentgens.

Thermal Conductivity of Aircraft Engine Lubricants at Low Temperature

Thermal conductivities and thermal diffusivities of a representative aircraft-gas-turbine lubricant and a representative piston-engine lubricant were determined over a temperature range of -100° F to 80° F. Average results of 0.75 Btu per hour °F ft for the turbine lubricant vs 0.090 Btu per hr °F ft for the piston lubricant indicate the considerable differences in thermal conductivity between the materials and the hazard in applying existing empirical relationships. The thermal conductivity of the turbine lubricant varied linearly with temperature, while the thermal conductivity of the piston engine lubricant varied irregularly due to wax separation.

Transition Temperature for Surface Damage in Sliding Metalic Contact

In inert gaseous atmospheres, repetitive sliding of nonalloying metallic couples produce low friction, smooth and relatively low rider contact area, and a narrow, smooth wear track on the mating disk, according to observations presented in this paper. A transition temperature is reported for the various liquids tested, below which sliding by shear is observed and above which sliding by welding occurs.



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TEMPERATURE CONVERSION CHART

Time saving temperature conversion charts are now available for the busy engineer or student who has occasion to convert Fahrenheit temperatures into Centigrade equivalents.

In addition, the reverse side of the handy 8½" x 3½" chart illustrates by means of animation the easy reading qualities of thermometers made with the Moeller Glass Red Reading Column. This chart can easily be carried in pocket or wallet or placed under glass-top desks for easy reference. For chart, write to Moeller Instrument Company, Richmond Hill 18, N. Y.

MOLY-SULFIDE AS A FILLER

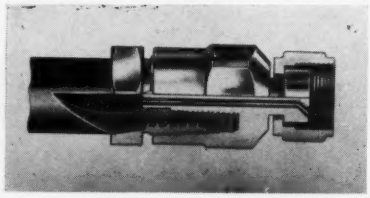
A four-page bulletin describes the development of molybdenum disulfide, designed to improve the frictional and mechanical properties of certain plastic materials.

Use of the powder as a filler in nylon, phenolic laminates, Teflon and other plastics, plus natural and synthetic rubber and asbestos should result in lowered surface friction, increased wear resistance, increased resistance to cold flow, improved dimensional stability, and increased thermal conductivity. (Bulletin LU-12, Climax Molybdenum Co., Dept. 1. 500 Fifth Avenue, New York 36, N. Y.)

FLUID TRANSFER

Vac-U-Max Tank Kit utilizes a vacuum for fluid pick up and transfer into standard sealed drums or larger tanks. Compressed air passing through a jet venturi creates a constant high-suction vacuum, and solvents, cutting oils, coolants, chemicals and fuels for reclaiming or disposal are reported safely handled without explosion or other hazard. The unit is portable. For further information, write: F. P. Pendleton, Vac-U-Max Sales Co., 1 Montgomery St., Belleville 9, N. J.

SURGEPRUF HOSE AND COUPLINGS



Skiving rubber-covered wire braid hose can be eliminated with the newly introduced Surgepruf medium-high and high pressure hydraulic hose and hose couplings.

Indefinitely reusable, they bite through rubber coverings, solidly gripping single or double wire braid hose without weakening protective coverings and are usable in operating temperature ranges from —40 to 275 degrees F. and burst ranges from 1,400 to 18,000 pounds psi. For more information, write: Public Relations Dept., Stewart-Warner Corp., Alemite Div., 1826 Diversey Pkwy., Chicago 14, Ill.

"GUIDE FOR SELECTING VALVES, BOILER MOUNTINGS, LUBRICATING DEVICES", now published in a revised edition by the Lunkenheimer Co., presents new descriptive sections to augment the original 24 pages of tables, technical data, and information on the selection of valves, boiler mountings, and lubricating devices. Indexed for easy reference, the guide now offers additional data on LQ 600 Bronze Globe Valves; Luncor PVC All-Molded Valves, and Lunkenheimer Solder End Valves under the identification Circular No. 555, Valves (A.I.A. File No. 34). (Lunkenheimer Co., Cincinnati 14, Ohio)

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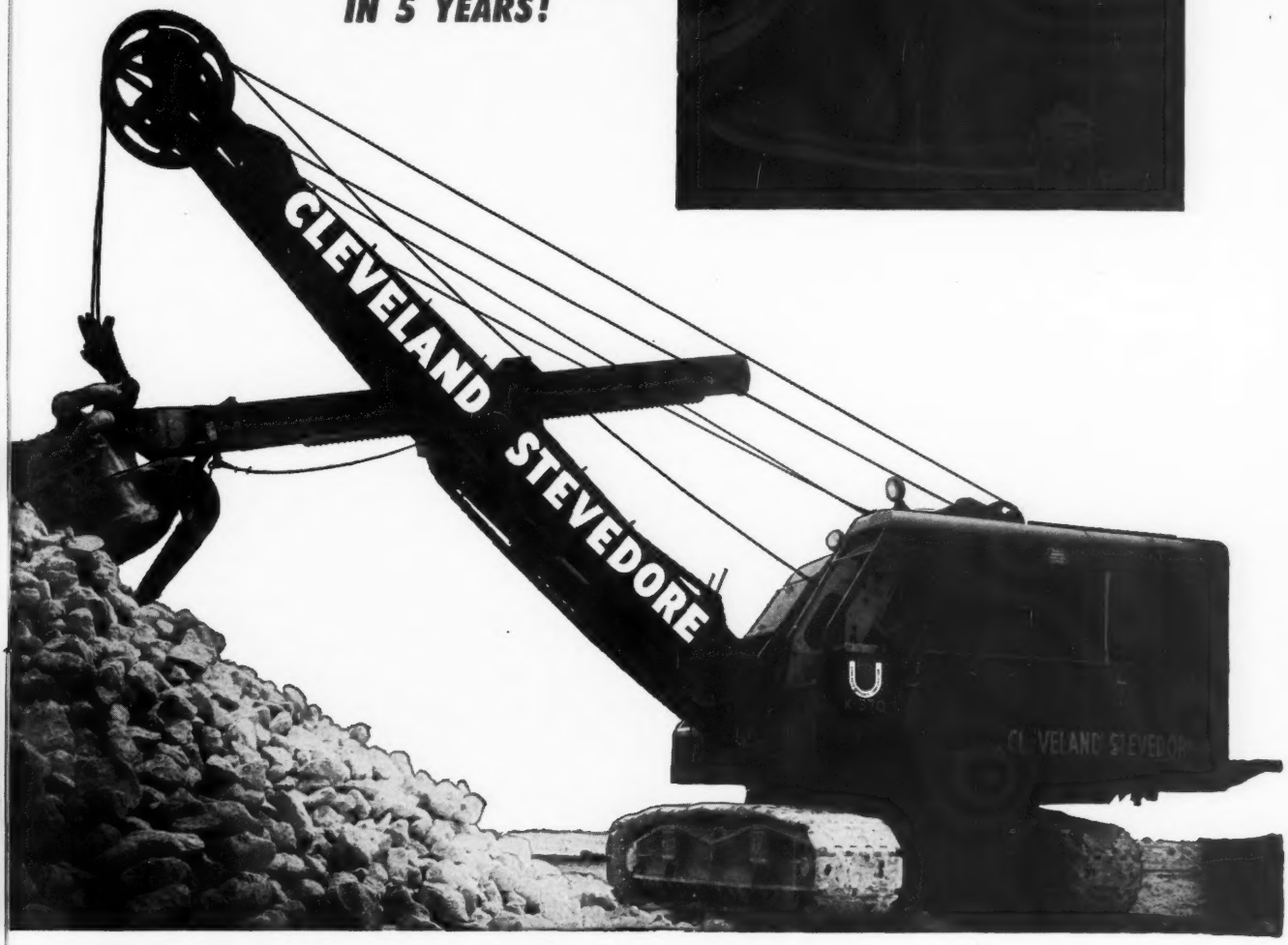

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Current Literature

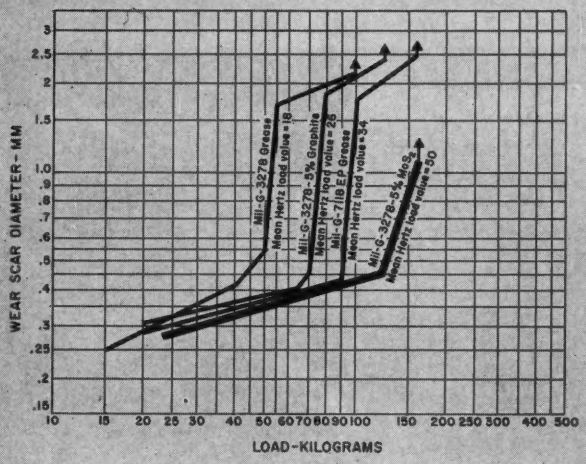
PUSH-TYPE SEMI-AUTOMATIC LUBRICATORS. Description, operation, and servicing of "One-Shot" lubricators, designed for use on machines requiring closely controlled but infrequent oil feed, is detailed in a two-page, two-color service instruction sheet. Two models of lubricators, actuated by a spring discharge piston pump feeding oil to lubrication points are described and four specification tables illustrate hose fittings, tubing, compression fittings and junctions used in Bijur lubrication systems. Servicing as many as 100 lubrication points, the "One-Shot" systems find application in textile machinery, small punch presses, and many specialized machines. (Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.)

"STANDARDS — GUIDES FOR TOMORROW" contains 24 papers presented at the 1956 annual meeting of the Standards Engineers Society in Washington, D. C. These range from standardization techniques in management and industrial areas through detailed work applications to standardization in the nuclear field, with outstanding experts who are also standards engineers discussing such subjects as: Antifriction bearing standardization, Standardization of Building Materials, Decimal Dimensioning, Standardization for the Median Size Company, Metals Standards, Screw Thread Standardization, American - British - Canadian Screw Thread Unification, Standardization of Drafting Practices, and U. S. Army Standardization. (Standards Engineers Society, P.O. Box 281, Camden 1, N. J. $3.75 for non-members, membership price $3.00)

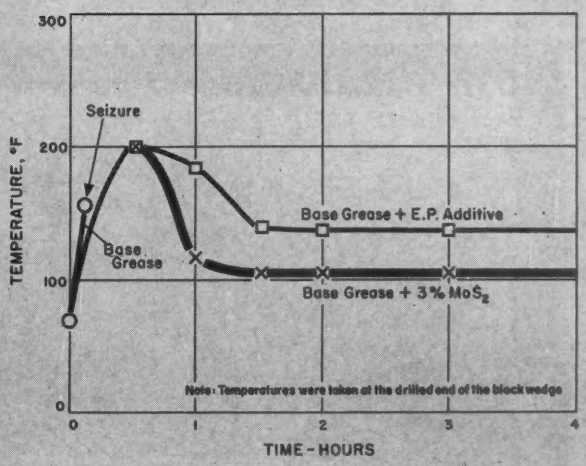
"SPRING DESIGN AND SELECTION — IN BRIEF" presents the fundamentals of spring design in quick easy-to-read form, yet in sufficient detail to guide the product designer through the initial stages of a spring design problem. The eight-page brochure contains basic stress and deflection formulas, commonly used spring materials, typical applications, and certain limitations for each of the various types of springs, from round-wire compression to hair-springs. A tabulation of the tensile, torsional, and other physical properties of the commonly used spring materials, and manufacturing process and end use notes form a useful part of the manual. Fifteen charts and graphs also contribute to its comprehensiveness as an analysis of spring design and selection. (Associated Spring Corp., Bristol, Conn.)

CONVEYOR TERMS AND DEFINITIONS. For those who continue to be puzzled by terms in this specialized field, Manual B75.1-1956 of the Conveyor Equipment Manufacturers' Technical Committee provides clear definitions of words like syncrolator, skip hoist, or bifurcating feeder. Each type of conveyor is defined in terms of what it is, rather than what it does, providing a uniform vocabulary for the specification, manufacture, installation, and use of all types of conveyors. Beginning with a general definition of the word "conveyor" itself, terms and their definitions follow alphabetically throughout the 64-page booklet. Extensive cross-indexing is included to facilitate use of the glossary. (American Standards Association, 70 E. 45 Street, New York 17, N. Y., $1.00)

RESIN DATA. A new folder, "Price List M", contains in addition to price information on analytical grade anion exchange resins, cation exchange resins, and monobed resins, considerable additional data of potential value to the laboratory worker. A section on selection of a specific ion-exchange resin discusses the effects of anion exchanger functional groups, cross-linkages, and particle sizes. This information is related to an extensive tabulation of four resin group properties. Data on effective pore size, swelling volume, and exchange capacity is included with a list of specific resins for production and a bibliography of works on the subject of ion exchange (Bio-Rad Laboratories, 800 Delaware Street, Berkeley, Cal.)


WEAR SCAR DIAMETER - MM
LOAD - KILOGRAMS
Mil-G-3278 Grease
Mean Hertz load value = 18
Mil-G-3278 - 5% Graphite
Mean Hertz load value = 26
Mil-G-7118 E.P. Grease
Mean Hertz load value = 34
Mil-G-3278 - 5% MoS2
Mean Hertz load value = 50

4-ball E.P. test shows the superior extreme pressure properties of MoS_2 grease over the same grease without additives. In the same test, grease containing 5% graphite had a mean Hertz load value of 26; the conventional E.P. grease Hertz value was 34.


TEMPERATURE, °F
TIME - HOURS
Seizure
Base Grease
Base Grease + E.P. Additive
Base Grease + 3% MoS2
Note: Temperatures were taken at the drilled end of the block wedge

Timken endurance test clearly shows how MoS_2 functions when added to a base grease. With base grease alone, the specimen seized in about 10 minutes. With MoS_2 added, lubrication was effectively sustained throughout the test at a reduced temperature of about 100°, compared with a temperature of about 130° for the conventional E.P. grease.

Moly-Sulfide additive extends effective lubrication

Laboratory and field tests prove that chassis lubricants containing MoS_2 sustain lubrication after base grease is wiped off

When standard chassis greases are first applied to shackle pins, ball points and other bearing points under trucks, trailers and passenger cars, excellent results are obtained. These greases, however, are subject to mechanical motion, such as reciprocation, pressure, oscillation and shock loading which tend to eject the lubricant.

At this point, chassis grease containing 3% Moly-Sulfide proves its great value. MoS_2 is forced between the rubbing surfaces, adheres to the metal and forms a protective film that prevents galling, welding and fretting. The extent to which MoS_2 sustains lubrication is demonstrated by substantial reduction in wear.

Four tests show how MoS_2 reduces wear

1. **Shell 4-ball extreme pressure test** (see illustration) —MoS_2 addition reduces wear more than 50%, increases load capacity about 70% over base grease.

2. **Falex 2-hour wear test**—As the chart here shows, MoS_2 sustains lubrication, as proved by a reduction in wear, by an average factor of 500.

Grease	Loss in weight of specimen
Lithium-base	1,000 mg.
Lithium-base plus 2% MoS_2	1.98 mg.—average of 3 runs

3. **Timken endurance test** (see illustration)—MoS_2 sustains lubrication well beyond the capabilities of the base grease alone, and at a lower temperature than conventional E.P. grease.

4. **Simulated shackle bolt service test**—oscillating friction machine—3% MoS_2 addition virtually doubles the effective lubrication of a lithium base chassis grease —is far more effective than conventional additions.

Hours to failure—average of 2 tests

Additive	None	3% MoS_2	5% ZnO	15% ZnO
Dry	350	564	336	555
Wet	162	264	109	85

On-the-road use proves MoS_2 prevents chassis wear

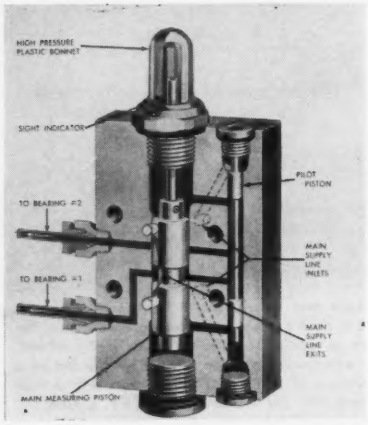
A St. Louis company reports no noticeable wear on chassis parts of auto transport trailers, since they selected an MoS_2 chassis grease.

Based on their own tests, several major automobile and truck manufacturers use—and recommend—MoS_2 grease for torsion suspension units, ball joint suspension, as well as for many other critical-wear areas.

Moly-Sulfide greases are available from many producers today. For a list of the manufacturers of these greases—which includes several major oil companies—and for a copy of "Molybdenum Disulfide as a Grease Additive," write to Department 38, *Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y.*

New Products

LUBRIVAL



A circulating oil system introduces several principles to the field of circulating oil. Some of the features of the Lubrival system are: (1) No restriction is set on the number of bearings served from a manifold group of valves. (2) The positive piston displacement method is used to feed lubricant to the bearings. The main measuring piston acts as a flow-shuttling piston in addition to metering the lubricant. (3) Due to full supply line pressure is delivered to every measuring valve in the system. The system provides a warning for broken discharge lines. For 8-page illustrated brochure, write to The Farval Corporation, 3249 E. 80th Street, Cleveland 4, Ohio.

AUTOMATIC TANK SELECTOR SYSTEM

A new automatic tank selector system, said to promise cost savings in petroleum, chemical and related industries has been developed to control filling of storage and settling tanks. The system uses a pneumatic circuit, with selector-controller and level transmitters directing operation of pneumatic fill valves.

In a one second per tank operation, the selector-controller senses the liquid level of each tank in the system through the level transmitter, automatically opens the fill valve if the tank requires filling or cycles to the next tank if filling isn't required. Each circuit can handle up to 12 tanks, and two or more selectors can be connected in series to control any number of tanks. Write for Temporary Bulletin 212, Dept. ATS Mason-Neilan, 60 Nahatan St., Norwood, Mass.

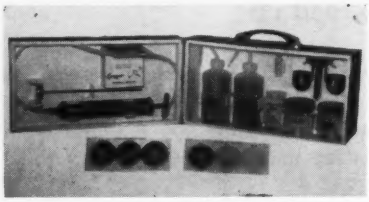
ROLLSET BEARINGS

A combination of stud and nylon rollers, rollset bearings utilize a nylon roller whose self-lubricating quality should assure quiet operation, smooth rolling action, and resistance to wear under loads. The stud can be produced from either zinc or cadmium plated steel, stainless steel or aluminum, and is left soft for riveting. For more information, write to: General Bearing Co., Inc., 47 Roselle St., Mineola, N. Y.

HYDRAULIC SUMP FILTER

A one-piece, sintered hydraulic sump filter gives controlled depth of filtration providing a large filtering area with negligible pressure drop. The simplicity of the one-piece design is claimed to make low cost replacement possible with minimum downtime. Write for Bulletin SF-357, Arrow Tools, Inc., 1923 S. Kostner Ave., Chicago 23, Ill.

OIL TESTING KIT



A portable oil-testing kit measuring harmful contaminants in used engine oil is now available. Designed for use by the armed forces, it is claimed to determine within minutes whether engine oil is still in satisfactory condition or whether it contains excessive solids, dilution or corrosive acids and should be changed. For further information, write: Lengor, Townsworth Bldg., Annapolis, Maryland.

TEMPLATE RULER

All design engineers whose companies are currently using or planning to use Minnesota Rubber & Gasket Company's Quad-Ring seal will be given a template-ruler to provide for faster and more accurate drawings of the firm's seal.

NEW...
EMERY 3033-S
LUBRICANT ESTER...

a new-type diester base for synthetic lubricants

Emery 3033-S is a new-type dipropylene glycol diester based on pelargonic acid, a unique, C_9, saturated, monobasic acid.

It is currently in use or under test in the following three areas: 1) Synthetic greases for spec. Mil-G-3278-A Low Temperature Aircraft Grease; 2) Low-cost blending component for synthetic low-temperature lubricating fluids meeting Mil-L-7808 C; and 3) synthetic lubricant base fluid for civilian lubricants in aircraft, automotive and specialty uses.

Since 3033-S is based on a relatively low-cost acid, pelargonic acid, long-range economics are favorable. Also, availability is not contingent on strategic, imported raw materials since pelargonic acid is made from abundantly available domestic fats and oils.

Though 3033-S is in a development stage, it is available in tankcar quantities on reasonable notice.

Mail coupon below for Technical Bulletin titled "Emery 3033-S Lubricant Ester" for complete characteristics and performance data in synthetic greases and fluids.

Emery

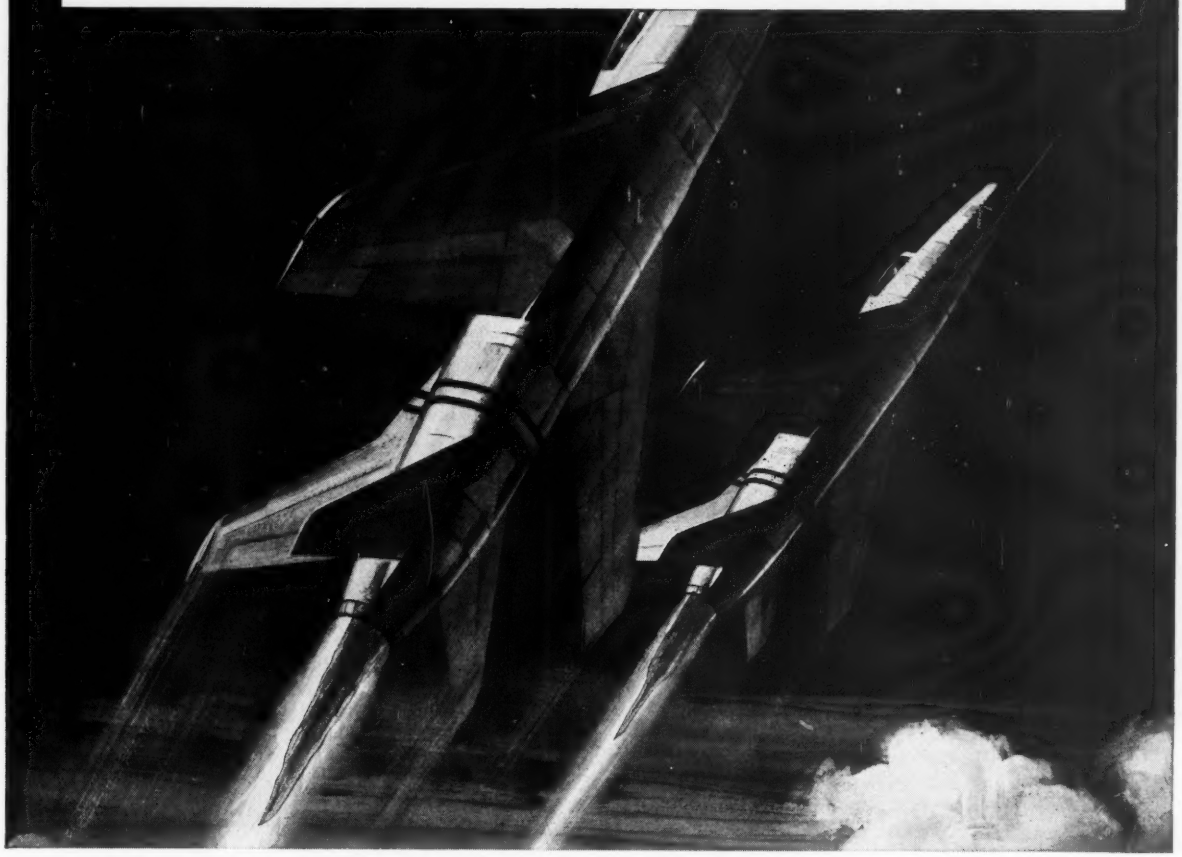
Development and Service Department
Emery Industries, Inc.
Carew Tower, Cincinnati 2, Ohio

Emery Industries, Inc.
Dept. Y-6A, Carew Tower
Cincinnati 2, Ohio

Please send Development Product Bulletin #60 on Emery 3033-S.

Name.....
Company.....
Address.....
City.....State.....

from EMERY...EMOLEIN® AZELATES
for the extreme lubrication performance Jet Engines require



MEETS BOTH MILITARY AND CIVILIAN REQUIREMENTS

Synthetic lubricant fluids that meet both military (Mil-L-7808-C) and civilian specifications are now being compounded from Emolein Azelates (diesters).

The excellent performance of these new diesters, Emolein 2957 di-iso-octyl azelate and 2958 di-2-ethylhexyl azelate in lubricants designed to meet the extreme heat and cold performance qualities required by jet engines, is attributed to the following combination of properties:

1) excellent temperature-viscosity performance even at high and low temperature extremes... 2) high viscosity index... 3) low pour points... 4) excellent lubricity... 5) oxidation and corrosion stability... 6) high flash and fire points... 7) excellent additive response.

Produced from non-strategic raw materials

Since the Emolein azelates are based on azelaic acid obtained from domestic fats and oils abundant in supply, availability is not contingent on strategic imported raw materials. Also, future plant expansion is being carefully coordinated with the broadening utility of these diesters.

Application in other synthetic lubricants

Other military specifications met by synthetic fluids and greases compounded from Emolein Azelates include: Mil-G-3278 A, Grease, Aircraft and Instruments-Low and High Temperatures; Mil-L-6085 A, Lubricating Oil, Aircraft Instruments, Low Volatility; and Mil-L-6387 A, Lubricating Oil, Synthetic Base.

Mail coupon below for full technical information.

Emery **Organic Chemical Sales Department**

Emery Industries, Inc., Carew Tower, Cincinnati 2, Ohio

Emery Industries, Inc., Dept. Y-6, Carew Tower
Cincinnati 2, Ohio

Please send me a copy of your 16-page Technical Bulletin No. 409 titled "Emolein Esters for Synthetic Lubricants."

Name.....Title.....

Company.....

Address.....

City.....State.....

Advance Information!

4th Joint Lubrication Conference

Co-Sponsored by ASLE-ASME

Papers currently being considered by the reviewing committee—

"The Effect of Aircraft Gas Turbine Oils on Roller Bearing Fatigue Life"

"Extremely Thin Film Hydrodynamic Lubrication"

"A Solution for the Finite Journal Bearing & Its Application to Analysis and Design — III"

"A Theory of Cutting Tool Wear & Cutting Oil Action"

"Solid Film Lubricants at High Temperatures"

"Investigation of Factors Governing Rolling Contact Fatigue Life in the NACA Fatigue Rig"

"Wear of Cobalt-Base & Stainless Steel Materials in High-Purity Water"

"Influence of Lubricants on Gear Fatigue"

"A Study of Piston Ring Face & Side Wear Characteristics by the Radioactive Technique"

"A Study of the Effect of Wear Particles & Adhesive Wear at High Contact Pressures"

"Lubricity Studies Under Extreme-Temperature Conditions"

"The Role of Atmospheric Oxidation in High Speed Sliding Phenomena"

Watch *Lubrication Engineering* for further information on this important conference.

4th Joint Conference of the ASLE-ASME
October 7, 8, & 9, 1957

Royal York Hotel
Toronto, Ontario, Canada

Personals

Horizons, Inc., a Cleveland materials and process research organization, has a new director of sales.

He's Robert A. McIntyre, former assistant to the president of Designers for Industry where he was responsible for activities of comercial sales representatives.

In his new capacity, McIntyre will direct Horisons' sales program throughout the United States and Canada.

The new sales director has been associated with the Engineering Experiment Station of the Georgia Institute of Technology, as well as with the Ferro Corporation.

Robert F. Barge has been named sales engineer for Flexonics Corporation's Lake Erie and St. Lawrence area.

In his new position with the Maywood, Ill. firm, Mr. Barge will be responsible for sales and service engineering to Flexonics' customers, distributors and agents in the industrial areas of Ohio, Pennsylvania and New York.

He formerly managed the Cleveland branch office of Goodall Rubber Co., Trenton, N. J.

Tom Welsh has been appointed to the newly created post of Eastern Sales Manager at Snap-Tite, Inc., manufacturers of quick connect-disconnect couplings. He had previously been assistant sales manager with the company for the company for the past four years.

Appointment of John W. Puth as advertising manager for Purolator Products, Inc., automotive and industrial filter manufacturer, Rahway, N. J. has recently been announced. Four representatives for the sale of Purolator bulk filters have also been named. They are: Lufkin Engineering Co., Boston, Mass.; Gould Equipment Company, Portland, Me.; Fargo, N. D.; Ezell Equipment Co.; Atlanta, Ga. to cover their respective regions.

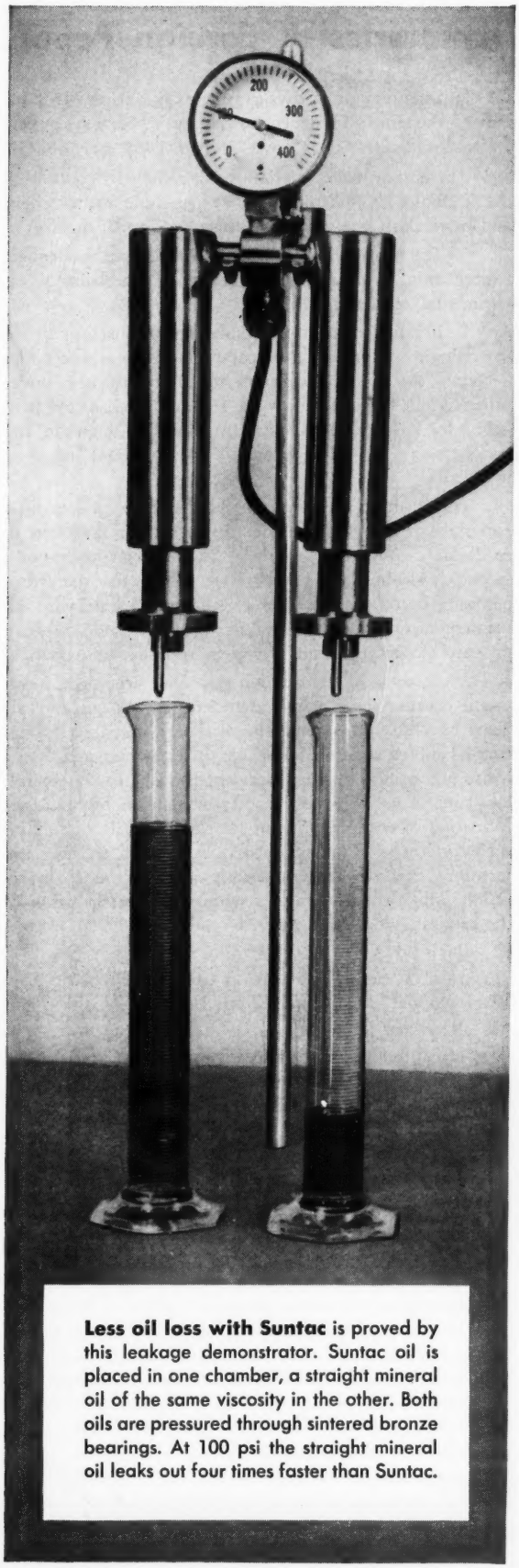
Robert P. Rice has joined American Potash & Chemical Corp. as chief control chemist at the company's Henderson, Nev. plant.

JONATHAN KLUDT

Jonathan Kludt has been elected Executive Vice President and General Manager of the Lincoln Engineering Co., a division of The McNeil Machine & Engineering Co., Akron, Ohio.

The L. R. Kerns Co., Chicago, Ill. manufacturer of metal-processing compounds, has announced the opening of the Kerns Pacific Corp., a wholly owned subsidiary located in Orange, California. Arnold F. Kluenders will be vice president in charge of operations and A. L. Spalding will be vice president, sales.

The A-P-D Co., recently-organized affiliate of Minnesota Rubber & Gasket Co., have announced the appointment of R. E. Tisch as vice president, product development, and W. A. McGee as vice president, materials development.



Less oil loss with Suntac is proved by this leakage demonstrator. Suntac oil is placed in one chamber, a straight mineral oil of the same viscosity in the other. Both oils are pressured through sintered bronze bearings. At 100 psi the straight mineral oil leaks out four times faster than Suntac.

LEAKAGE DEMONSTRATOR PROVES SUNTAC CAN CUT OIL LOSS AS MUCH AS 75%

Expensive equipment overhauls to stop leaks in hydraulic systems can often be avoided by a change to Suntac®. The exceptional antileak characteristics of Suntac oils can reduce oil losses as much as 75%, as can be proved in the leakage demonstrator. *Some users have reported actual drops in oil leakage of 90%.*

Suntac oils give you lower lubrication costs, cleaner equipment and floors, safer working conditions. Their leak-reducing agent leaves no gummy film or residue. In addition, Suntac oils are fortified against oxidation to lengthen oil life...against rust and corrosion to lengthen equipment life.

You'll find Suntac a money and time saver in your hydraulic systems...and a high-quality general-purpose oil for many other uses.

WANT MORE SUNTAC FACTS? Ask your Sun representative for Technical Bulletin 23. Or you can get full details, prices, and delivery information by writing to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. LE-6.

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LUBRICANTS
High temperature lubrication got you on the "hot spot"? Cheer up. There is an economical solution to your problem — Dow Corning SILICONE oils and greases. These heat, cold and oxidation resistant lubricants stay put and provide long-time lubrication at operating temperatures far above and below the limits of even the best organic oils and greases. Reduce relubrication and maintenance costs with Dow Corning SILICONE lubricants.
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ASLE JEWELRY

The new ASLE jewelry is available in the form of tie clasps, lapel pins, or cuff links at $3.50, $1.50, and $4.50 each, respectively, from the National Office. Many of the Sections are using the jewelry in their membership campaigns. Details are available through the National Office.

Summaries of Foreign Papers

"A Commentary on Views as to the Oxidation Mechanism of Paraffinic Hydrocarbons," by V. K. Tsykovsky, *Zhur. Priklad. Khim. USSR, Vol. 28,* 1955, pp. 735-737.

The author makes the following comments concerning the literature on the oxidation of paraffinic hydrocarbons and particularly the work by Langenbeck and Pritzkow:

1. The proposed hypotheses are based upon inadequate experimental evidence and improper interpretation of experimental results.

2. It is not sound to generalize the conclusions reached in studying the oxidation of paraffinic hydrocarbons under a certain set of test conditions to cover oxidation under other conditions, or to apply the reaction mechanism established for a few selected pure hydrocarbons (tetralin and cyclohexane) to other paraffinic hydrocarbons or their mixtures.

For example, Langenbeck and Pritzkow state in their paper that the hydroperoxide formed in the first step of oxidation can decompose only to form either a ketone or a secondary alcohol. They reject Rieche's idea that the hydroperoxide decomposes to the corresponding aldehyde and primary alcohol on the basis that neither aldehyde nor primary alcohol is found in the end product of oxidation.

The author is of the opinion that their argument is not sound because these active intermediates are quickly oxidized into fatty acids almost immediately after their formation. He then states his view that, in a complex mixture of hydrocarbons, the decomposition of hydroperoxide can follow simultaneously several routes which will result in the formation of entirely different intermediates, depending on such conditions as temperature, time, catalyst, etc. He also mentions that the catalyst merely initiates the chain reaction, which then propagates without the participation of the catalyst. (*Reviewed by I-Ming Feng*)

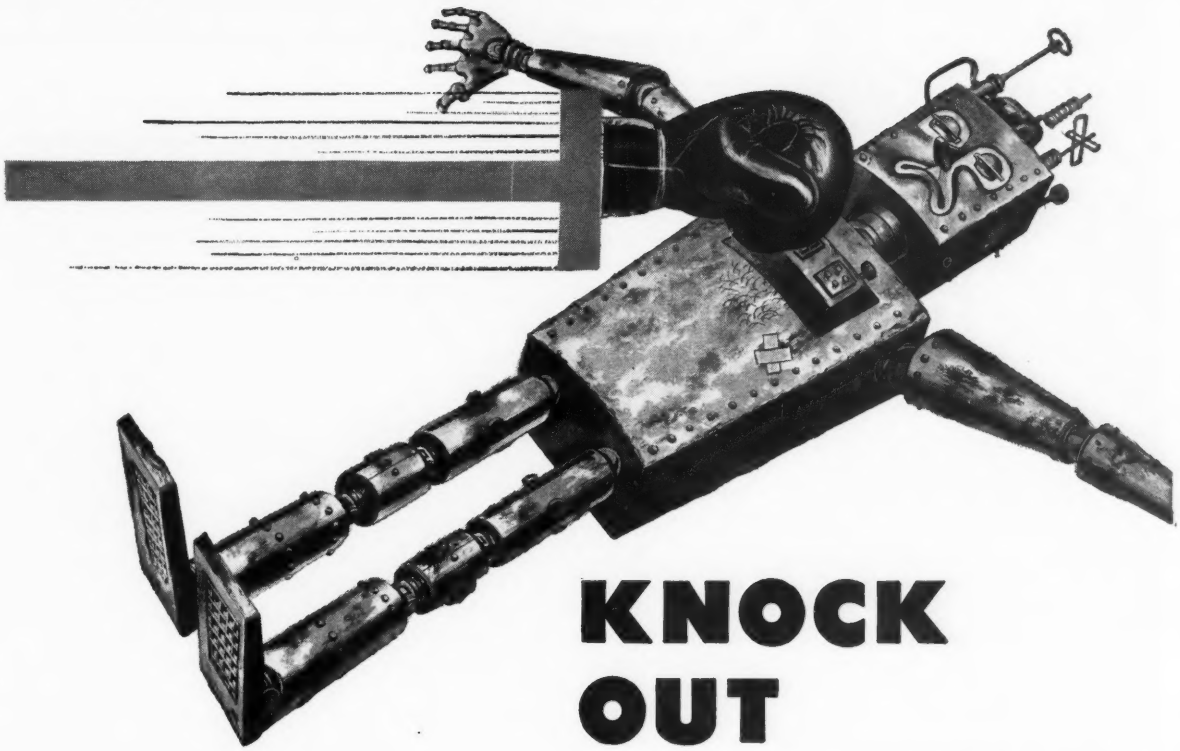
"Friction, Wear & Lubrication in Wire Drawing," by W. Papsdorf, *Stahl und Eisen, Vol.* 72, No. 8, 1952, pp. 393-399.

The author surveys briefly the early use of lubricants in wire drawing and presents recent theories concerning friction. Wire drawing coefficients of friction fall within the region of boundary friction ($\mu f = 0.02$ to 0.2). Differences in roughness of boundary surfaces cause differences in μf exceeding one power of ten even when the same lubricant is used.

A wire drawer is concerned particularly with the wear of the die and whether the drawn wire meets tolerance specifications. The wearing down of the peaks or asperities on the surface of a new die produces rapid wear in its early life. A longer period, the useful life of the die, represents slow, uniform wear. After a certain tonnage of wire is drawn, the die again wears rapidly due to abrasion particles from the mouth of the die. This abrasion is probably caused by cavitation or greatly fluctuating compressive stresses. The die's useful life is ended. The output of a die is expressed in tons of wire per 0.01 mm. of increase in die diameter.

In wire drawing, the specific surface pressures are con-

Continued on p. 321



KNOCK OUT CORROSION WITH ALKATERGE-T

Alkaterge-T is fulfilling its early promise of being an exceptional oil-soluble corrosion inhibitor. It passed two commonly used screening tests with the most gratifying results and industrial users are finding confirmation in practice.

At least part of its success is probably due to its very powerful adhesion to metallic and other hydrophilic surfaces. The force required to break this adhesion has been measured at 10,500 psi — highest of any compound tested. Alkaterge-T is a big molecule and with this adhesion, powerful protection would be expected by most corrosion engineers. But Alkaterge-T has a plus value, too. Mildly alkaline, it will tie up any trace of acidity that may develop, yet it is harmless to brass. This product, therefore, should be evaluated by every manufacturer of rust preventive oils, lubricants, cutting oils, extruding oils, transformer oils, corrosion resistant greases, and spinning and throwing oils for the textile industry.

Alkaterge-T is a powerful emulsifying agent for water-in-oil emulsions and is unaffected by hard water. As little as 1% will emulsify 80% water into aliphatic hydrocarbons and form a fluid, stable emulsion. In lubricating formulations, Alkaterge-T tends to prevent sludge formation resulting from moisture pickup and should be of interest in crank case flushing oils and fuel oils. It should also be evaluated as a liquefier for the water-in-oil sludges that present severe problems in automobile crankcases, fuel oil tanks and crude oil production.

For further information and samples, write Commercial Solvents Corporation today.

ALKERTERGE-T TYPICAL PHYSICAL PROPERTIES

Color (melted), Gardner (1933)	12 max
Solidification Point, °C	59
Interfacial Tension against water, 0.1% solution in mineral oil	1.8 dynes/cm
Surface Tension, saturated aqueous solution	30.4 dynes/cm
Flash-Point	None
Solubility in water at 25 °C	0.01 ml/100 ml

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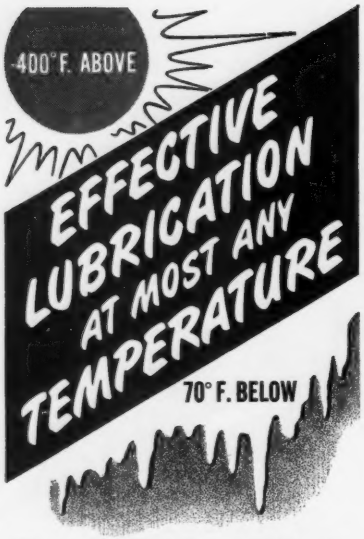
IN CANADA: Reliance Chemicals, Ltd., Montreal. IN MEXICO: Comsolmex, S. A., Mexico 11, D. F.



The fact that LUBRIPLATE Lubricants are able to meet extreme temperature conditions demonstrates the ability of these products to cope with the wide variations found in everyday industry. Besides this feature, LUBRIPLATE Lubricants possess attributes not found in conventional lubricants.

HIGH TEMPERATURES

LUBRIPLATE No. 930-AA.—Provides superior and protective lubrication for all types and sizes of machines operating at temperatures as high as 500°F. Possesses exceptionally high film strength and adhesiveness. Protects all metallic parts against rust and corrosion.

LOW TEMPERATURES

LOW-TEMP LUBRIPLATE—The outstanding multi-purpose grease type lubricant that will remain plastic at 70°F below Zero, yet has a Melting Point of 270°F. Resists water and acids—protects against rust and corrosion even from calcium chloride used on paved roads during winter months.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Write for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. LUBRIPLATE DIVISION, Fiske Brothers Refining Company, Newark 5, N. J. or Toledo 5, Ohio.

Personals

L. B. Sargent, Jr. has been appointed to chief of the lubricants division of the ALCOA research laboratories. Spencer R. Milliken and Wendell Milz have been appointed assistant chiefs of the division.

E. M. Kipp, formerly of the ALCOA laboratories, has been appointed director of research for Foote Mineral Co. in Philadelphia.

Garlock Packing Co., Palmyra, N. Y. has announced the election of Donald F. Fraser and Albert J. McMullen as vice presidents of the company.

Frederick S. Burrell has been appointed Chief of the Engineering Mechanics Section, Franklin Institute Laboratories for Research and Development. The section will expand its services and will include basic studies and engineering applications for fluid mechanics.

John Boyd, Manager, Lubrication Section, Westinghouse Research Laboratories, Pittsburgh, was the April lecturer at the Mechanics Colloquium of the Illinois Institute of Technology, Chicago. He lectured on "Principles of Lubrication."

Cleveland Worm & Gear Co. and its affiliate The Farval Corporation have announced the election of George H. Acker as President and Howard Dingle as Chairman of the Board of both companies.

Thomas N. Deane has been appointed Sales Manager of Bray Lubricants Co., Richmond, Calif.

Union Carbide and Carbon Corporation has changed its name to Union Carbide Corp. and three of its divisions' names have also been changed. Carbide and Carbon Chemicals Co. will be known as Union Carbide Chemicals Co.; Linde Air Products Co. has become the Linde Co.; and Carbide and Carbon Realty Co. has been changed to Union Carbide Realty Co.

Kenneth M. Watson, formerly vice president of Pure Oil Co., has been appointed to the staff of the Illinois Institute of Technology. Mr. Watson will teach and provide research in the fields of kinetics and thermodynamics.

The Warren Refining and Chemical Co., Cleveland, Ohio has appointed Albert Meilus Chief Chemist in the Lubricating Division.

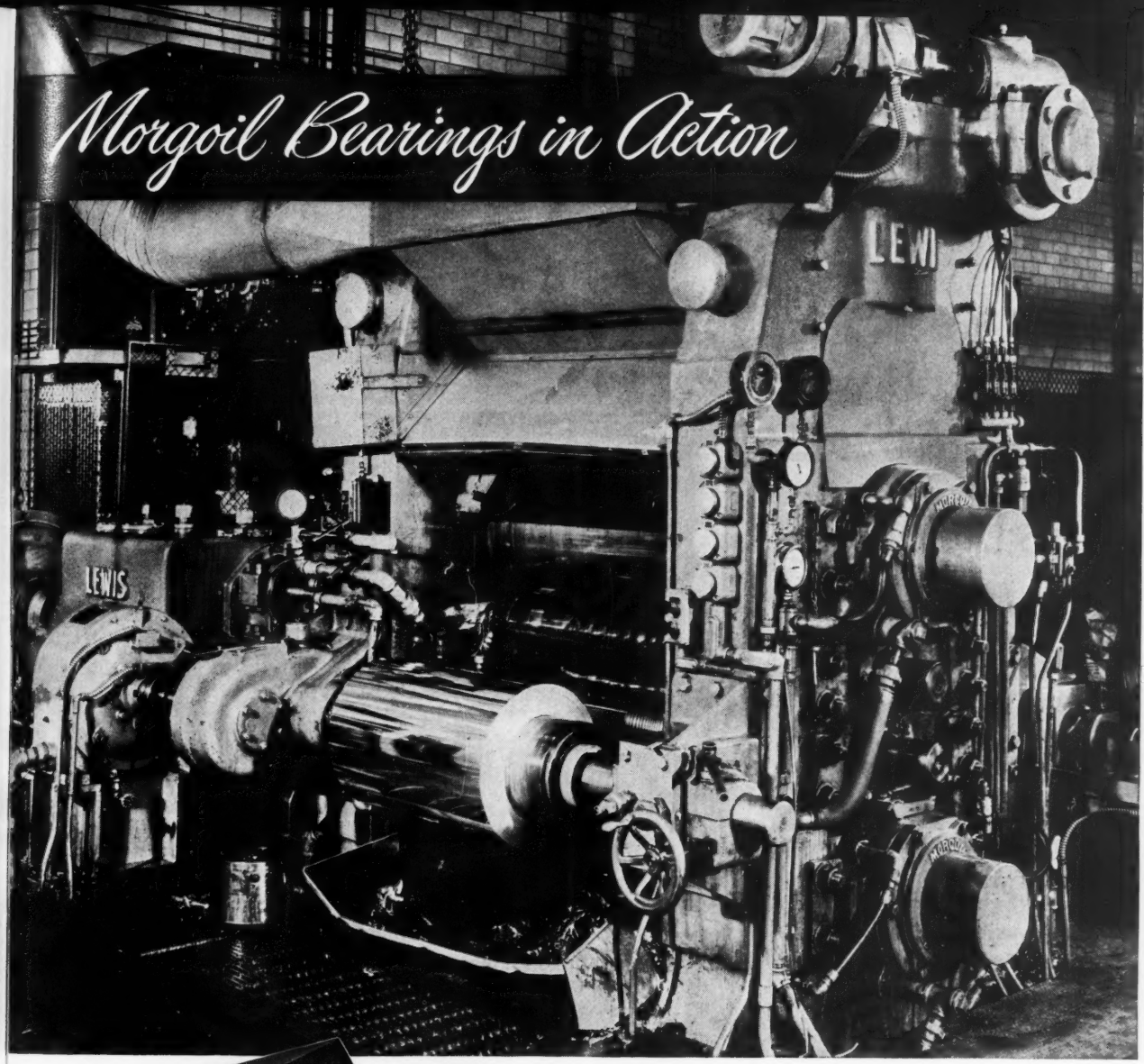
John D. Hetchler, formerly sales manager of the chemical products division, Archer-Daniels-Midland Co., has been appointed manager of a new chemical division of Werner G. Smith, Inc., Cleveland, Ohio. The division will expand the firm's present line of chemicals derived from oils and fats and chemically modified tall oils, animal tallow, sperm whale oils, and fish oils.

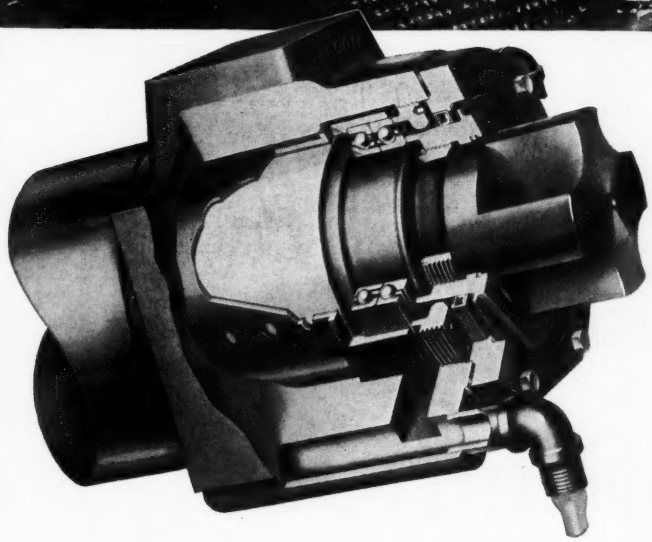
Professor **E. Saibel,** previously affiliated with the Carnegie Institute of Technology has joined the faculty of Rensselaer Polytechnic Institute as Professor of Mechanics.

HOWARD DINGLE

G. H. ACKER

Morgoil Bearings in Action





The 18″-72″ MORGOILS on the 9″ and 21″ x 44″ Aluminum Foil Mill at Cochran Foil Co. pictured above make it easier to produce a quality product at high speed. Foil as thin as .00025 of an inch is rolled at speeds approaching 4000 feet per minute on MORGOIL-equipped mills. MORGOIL BEARINGS give you freedom from wear and fatigue and permit operation at high speeds with remarkable long bearing life.

MORGAN CONSTRUCTION CO.

WORCESTER, MASSACHUSETTS

ROLLING MILLS MORGOIL BEARINGS GAS PRODUCERS
WIRE MILLS EJECTORS REGENERATIVE FURNACE CONTROL

MB-31

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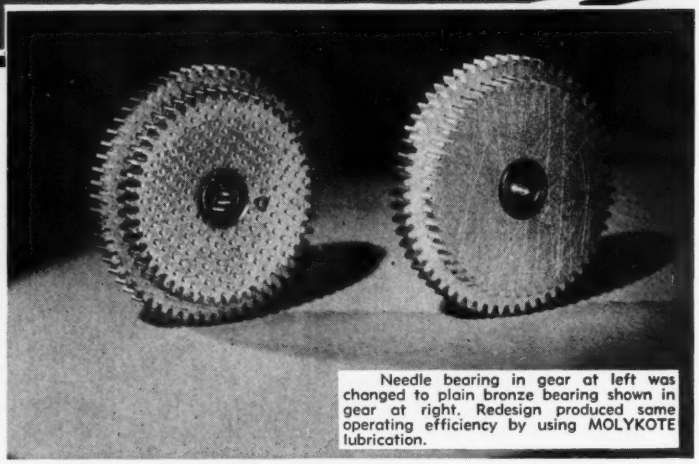
MOLYKOTE® lubricant sparks design change

SAVES EAGLE SIGNAL CORP., MOLINE, ILL. THOUSANDS OF DOLLARS ANNUALLY



Needle bearing in gear at left was changed to plain bronze bearing shown in gear at right. Redesign produced same operating efficiency by using MOLYKOTE lubrication.

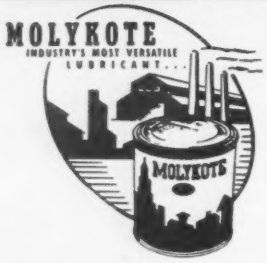
Eagle Signal Corp., Moline, Ill., manufactures the Polyflex Reset Timer, a synchronous motor driven device which trips its contacts open or closed during a time interval. The timer is a precision instrument used to control many industrial operations.

As part of the original design, a gear assembly called for a relatively expensive needle bearing. After experimenting with MOLYKOTE Lubricants, the company adopted a plain bronze bearing, lubricated with MOLYKOTE, which gave the same results as the more expensive needle bearing. The annual saving is estimated at several thousand dollars.

The application of MOLYKOTE, Type M-55, to the bronze bearing shows simplicity of operation as well as the small amount of lubricant needed.

MOLYKOTE, TYPE M-55, IDEAL FOR INSTRUMENT LUBRICATION

Type M-55 is a stable dispersion of sub-micron size molybdenum disulfide powder in a mineral oil. It is approved for mist lubricators and is ideal for instrument lubrication.



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The ALPHA MOLYKOTE Corporation

Main Factories: 65 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

ASLE Publications
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Interpreting Service Damage In Rolling Type Bearings

A manual on ball and roller bearing damage which includes drawings, tables, and 74 photographs for aiding in the classification and identification of the causes of many of the common types of bearing damage. $1.00 per copy.

"Lubrication Engineering" Decennial Index

Subject & Author Indexes listing the papers published in **"Lubrication Engineering,"** Journal of the American Society of Lubrication Engineers, in Volumes 1 thru 10 (1945 thru 1954). 50c per copy.

Petroleum-Type Hydraulic Fluids

Second in the series of ASLE monographs, covering Hydraulic Oil Specifications & Service Properties, Viscosity, Viscosity Index, Demulsibility, Oxidation Stability, Lubricating Value, Rust & Corrosion Preventive Qualities. $1.00 per copy.

Physical Properties Of Lubricants

First in the series of ASLE monographs, covering Viscosity, Density & Specific Gravity, Cloud & Pour Points, Flash & Fire Points, Carbon Residue, Neutralization Number & Interfacial Tension, Saponification Number, Emulsification, Specific Heat. $1.00 per copy.

Practical Lubrication, Vol. 1

Ten practical articles giving information fundamental to the carrying out of successful lubrication practices in industry: Cleaning Lubrication Systems, Coal Mine Lubrication, Grease Lubrication of Ball Bearings, Lubricating Grease, Lubrication Requirements of Gears as Seen by a Gear Engineer, Open Gear Lubrication, Planned Lubrication as a Part of Plant Maintenance, Reduction of Gear Failures, Seals & Closures, Steel Mill Lubrication from Management's Point of View. $1.00 per copy.

Indicate opposite title the number of copies desired, fill in your name and address, enclose remittance, and mail to:

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- GRAFO Dispersions containing pure electric furnace Colloidal Graphite are performance proved on industrial applications such as hot and cold forging, drawing, stamping, extrusion, die casting, wire drawing, impregnation, high pressures, high temperatures and many other uses.
- GRAFO water and alcohol dispersions form dry lubricating films for pre-coating billets, coating dies, and to prevent dripping, improve housekeeping and eliminate smoke and fumes.
- Whatever your lubrication problem there is a GRAFO Colloidal Graphite Dispersion to do your job better for less.

Write Us Regarding Your Special Problem.

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Summaries of Foreign Papers

Continued from page 316

tinuous and high (127,000 to 381,000 psi). Animal or vegetable oils and fats, which are exceptionally polar and adhere well to metal surfaces are required. The lubricants must resist the heat caused by friction and the deformation of the wire. The temperature of the wire leaving the die ranges from 100 to 200° C. Very high temperatures (up to 1000° C.) occur at the regions of local contact. The flatness of the viscosity-temperature curves of fatty oils is an additional reason for their superiority over mineral oils. Soaps, the salts of fatty acids, are useful wire drawing lubricants since they are highly adsorbed, have high melting points, and combine chemically with the iron wire surface to form iron soaps. The surface of the descaled wire is made up of "peaks" and "depressions." Frequently a lubricant carrier is used to cover these "peaks" and fill in the "depressions." The lubricant, consisting mainly of a mixture of sodium soaps, is forced between the polished wall of the die and the lime coated wire. Probably the sodium soap is converted to a calcium soap in the die; an iron soap is formed also. The lime to soap ratio used in wire drawing lubricants is important. Dry lubricants containing a high percentage of lime are satisfactory for coarse wire and rod sizes but not for drawing small wire sizes. There is a limiting lime content for any size wire or rod. Graphite and molybdenum disulfide have been used straight or as lubricant additives in wire drawing. They are especially useful at high pressures and temperatures. They blacken the wire surface of low- and high-carbon steels and are difficult to remove prior to galvanizing. (*Reviewed by E. H. Loeser*)

SIR WILLIAM SIEMENS *brought many inventions to the steel industry but none with a greater future than the electric furnace. Knowledge of the carbon arc dated back to 1800. Siemens put it to practical use in 1878, when he built and operated steel-making furnaces on both the direct and indirect arc principles.*

Even then, electric power was too costly, and carbon electrodes of too poor quality, for an electric furnace to operate commercially. It was another 11 years before a successful commercial direct-arc furnace began operating, in France. America's earliest commercial electric furnace (at Holcomb Steel Company, Syracuse, New York) produced its first heat April 5, 1905. It was of 4-tons capacity. Today there are 200-ton electric furnaces and total domestic capacity exceeds 11 million net tons.

Great Names in Steel Making #V

The growth of the steel industry has been so fabulous that it confers ever-increasing greatness on the work of its pioneers. What William Siemens originated, the industry has since developed to an importance beyond anything he ever dreamed.

This is equally true of more recent technological discoveries.

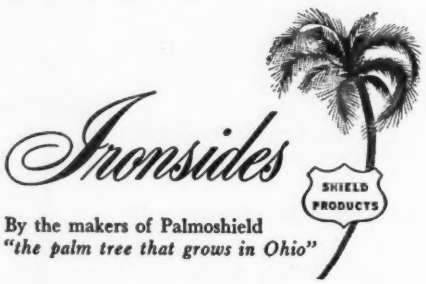
The lubricant Palmoshield, for example, was developed after World War II to replace imported palm oil for rolling tin plate. It was immediately recognized as an important discovery. But, since then, the importance of Palmoshield has been greatly increased by its successful use for the rolling of light and intermediate gauge sheet, and on long terne and coating lines as well.

Most of the rolling mills of North America are today aware that Palmoshield does much more than protect from dangerous dependence on palm oil from overseas. They appreciate that it eliminates the former need for stockpiling and all concern with artificially influenced prices and supply. They value the fact that Palmoshield is produced in the heart of the steel country, from available domestic materials, and under exact chemical control. Fatty acid content can be controlled within ½%.

Moreover, Ironside engineers can and do formulate Palmoshield to suit the mill speed, the method of application and the individual preferences of each user, and guarantee that the compound so developed will not vary in uniformity thereafter.

Ironsides lubrication specialists would like to work similarly with you, to help achieve objectives of increased tonnage, reduced costs, and maximum uniformity of mill production. A letter or phone call will bring you complete information and make available the experience of years of successful cooperation with America's major rolling mills.

Address The Ironsides Company, Columbus 16, Ohio.



By the makers of Palmoshield
"the palm tree that grows in Ohio"

JOS. MARGULIES.

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Write for informational bulletin containing technical data on Trona Lithium Hydroxide Monohydrate.*

*TRADEMARK AP&CC

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'ASPERITIES'... *a page of editorial comment and opinion*

Viscosity Classification*

During the forthcoming meeting of the ASTM in Atlantic City, N. J., June 17-21, the highly important question of an Industrial Viscosity Classification system will be discussed. Based on the recommendations of the various interests present, Committee D-2 of ASTM will recommend adopting a standard for industrial viscosity.

Perhaps it is wise to review some of the thinking which has led to the recommendations of the Technical Advisory Board, and subsequently, the ASLE.

The Viscosity Classification Sub-Committee of the ASLE questioned the need for and the requirements of a universal language to be used in discussing viscosity of industrial lubricants. They studied both proposal A and proposal B as submitted by ASTM and have made the following decisions:

1. Need for an Industrial Viscosity Classification System exists.
2. The accepted system must be completely independent of quality.
3. There must be rational relationship between grades.
4. A no-gap system is preferable.
5. The identification system must be simple and easily remembered.
6. Viscosity must be related to a standard temperature, unless otherwise stated.

Current systems (AGMA, SAE, and ASRE) now in use are confusing and inconvenient to use. A new system would establish definite tolerances to guide the manufacturer, consumer, and designer. It could lead to reduction of inventories by reducing specification and manufacturing overlaps. It should reduce the number of lubricants produced by offering a finite number of viscosity choices. It should simplify the purchasing, storing, and handling of lubricants as well as the design of equipment to be lubricated.

Other groups agree on certain requirements for an acceptable system: (1) based on temperature, but independent of quality; (2) continuous and without gaps; (3) based on a mathematical progression to permit extension in either direction; (4) should agree if possible with present systems; (5) should be based on kinematic viscosity with Seybolt equivalents shown for information; and (6) although desirable that the system reflect nominal viscosity, any simple, easily memorized method would be acceptable.

Accordingly, the Viscosity Classification Sub-Committee of ASLE recommends the adoption of proposal A of the ASTM. Its advantages include: a system based on a series of numbers, 1.0, 1.3, 1.6, 2.0, 2.5, 3.2, 4.0, 5.0, 6.3, 8.0, and 10.0, representing the nominal viscosity in centistokes. Nominal viscosity doubles every third step, and increases tenfold every tenth step. The basic series of numbers, with a shift of decimal point, repeats itself, and can be extended in either direction. More or less viscous materials can be included at a later date should the need arise without radical change in the system. Proposal B, which was rejected by the committee, involves a seven step system of wider tolerances (approximately 40% increase between grades as compared with 25% with the ten step system of proposal A.) Although the proposed system does not mention any specific reference temperature, it would probably be desirable to use some standard temperature, such as 100° F. If viscosity index or the viscosity at operating temperature is important, this must be stated separately. Petroleum manufacturers need not adapt brand names to the IVC code and therefore can market without loss of individuality and sacrifice of past trademark and brand identification promotion. Since tolerances will be specified, there will be no misunderstanding between designer, consumer or producer. Inconsistencies, such as a plus or minus 20% tolerance for a hydraulic oil and a plus or minus 10% tolerance on a less critical machine oil, will cease to exist.

Based on the recommendations of the TAB, the Board of Directors adopted the position taken by the TAB as the expressed opinion of the Society by board motion at their meeting April 17, 1957.

R. D. McCORMICK

*Compiled from a report of the ASLE Viscosity Classification Subcommittee to the Board of Directors, "An Industrial Viscosity Classification System" by R. C. Garretson, Minutes of the ASLE Board of Directors, Appendix III, April 17, 1957.

CONVENTION HIGHLIGHTS:

Left: A session of the well-attended lubrication engineering course held concurrently with the April Annual Meeting. Professor B. G. Rightmire (lower right with pencil) was the chairman.
Far Left: A general view of the main exhibit floor, part of the representative showing of booths and product demonstrations.

AUTOMOBILES AND AUTOMATION: *Detroit Noted Speakers Underline Role of*

LUBRICATING ENGINEERS throughout the world were drawn to the 22 technical and education sessions sponsored by the ASLE at Detroit's Sheraton-Cadillac Hotel, April 14-17. Over 1500 registrants participated in the technical sessions, committee meetings, lubrication engineering training activities, and exhibits presented by more than 35 industrial firms, making attendance the highest since ASLE's birth during World War II.

"Automation and Automotive Lubrication", selected as this year's convention theme, formed the discussion basis for more than 57 papers presented by noted scientists and engineers dealing with lubricants, control of friction, corrosion, mechanical design, and effective plant production techniques. Fifteen states and two foreign countries were represented by the speakers, who brought with them a good cross-section of Industry. Fields included Aircraft, Electrical, Government, Chemical, Education, Petroleum, Automotive, Glass, Independent Research, Mining, etc.

An outstanding convention event, the Annual Meeting Banquet on April 16, presented the ASLE National Award to Lubrication Engineer of the Year Dudley D. Fuller, professor of mechanical engineering at Columbia University and consultant on machine design to Aluminum Corp. of America and DuPont, in recognition "of his conspicuous service to the science of lubrication" through research, educational leadership, and contributions to the literature. Presented by ASLE Past President E. R. Booser, the award is held by Charles F. Kettering, O. L. Maag, F. P. Bowden and others. Also presented at the banquet were the Hunt Award, to Douglas Godfrey, California Research Institute, and the Hodson Award, to Ernest Rabinowicz, Massachusetts Institute of Technology. The Wilbur Deutsch Award

Left: The Annual Meeting Banquet was sparked by the efforts of top entertainers, including these strolling musicians. Right: And the ladies — who held two of these luncheon get-togethers as part of their tour of Detroit landmarks.

Convention Hears Lubrication Engineering

for the year's best paper on practices was not made.

J. O. McLean was elected president of the society, succeeding past president E. R. Booser. New directors named included A. B. Two, Ford Motor Co.; B. T. Harding, Midwest Oil Co.; and L. O. Witzenburg, Farval Corp. (Industrial Director). Other officers elected included J. D. Lykins, J. L. Finkelmann, J. W. Peterson, T. A. Marshall, R. F. McKibben, M. E. Dougherty, A. B. Wilder, and R. C. Dishington.

LUBRICATION IN PROGRESS

As automation increases, predicted a convention-observer, the influence of the lubrication engineer will probably expand. In effect, papers at the convention presented a progress report on the latest technological advances in lubrication engineering, dealing with subjects such as

ASLE Officers and Directors at the banquet speakers' table—this year without a speaker—as entertainment and relaxation set the pattern.

"Apparent Adsorption Isotherms of Oleic Acid from Hydrocarbon Solution as Obtained from Coefficient of Friction Measurements," and "Mass Study Data of Separator Effect on the Starting Torque of R4D Bearings."

Practical advances in lubrication were detailed in the numerous exhibits on the convention floor, which displayed the latest in lubrication equipment, products, and techniques permitting continuous operation of machinery and machine tools with a minimum loss in production time and materials, thus dramatizing the lubrication engineer's effort in the reduction of operating production costs and raising the standard of living on the consumer front.

Exhibitors bore out the statement "Lubrication is Big Business" by presenting over 35 booths featuring in graphic form the role of lubrication engineering in increasing machine life, safe plant operation, production rates, and reducing power requirements. Not only was quality maintenance dramatized, but equally that over half a billion gallons of lubricants and millions of dollars of equipment for their

Continued on page 359

This cocktail party gave members and guests a chance to get together before the banquet.

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Chrmn., Presidential Council

E. R. Booser.....General Electric Co.

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R. F. McKibben (Central)..Nat'l Cash Register Co.
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Abstracts .....W. E. Campbell, Afram Consultants
Annual Meeting (Cleveland) .....E. J. Gesdorf, The Farval Corp.
Annual Meeting Sites .....J. D. Lykins, Wheeling Steel Corp.
Awards.....D. W. Sawyer, Aluminum Co. of America
By-Laws .....A. E. Cichelli, Bethlehem Steel Co.
Editorial .....R. K. Gould, The Texas Co.
Education .....B. G. Rightmire, Massachusetts Institute of Technology
Finance.....C. C. Blaisdell, Penola Oil Co.
Handbook Advisory .....C. R. Schmitt, E. F. Houghton & Co.
Historian .....W. G. Fatch, U. S. Steel Corp.
Industrial Membership.....C. L. Willey, ASLE National Office
Journal Bearing Research .....E. M. Kipp, Aluminum Co. of America
Lubrication Conference .....E. E. Bisson, National Advisory Committee for Aeronautics
Membership & Admission .....B. M. Dunham, Sun Oil Co.
New Sections.....C. L. Willey, ASLE National Office
Nominations .....E. R. Booser, General Electric Co.
Program (Annual Meeting — Cleveland) .....H. W. McCulloch, Jr., Shell Oil Co.
Projects .....R. A. Kraus, Republic Steel Corp.
Tellers.....R. G. Grothus, Bell & Howell Co.

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Lubrication Fundamentals .....D. Godfrey, California Research Corp.
Lubrication Practices .....R. J. Torrens, Eastman Kodak Co.
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R. O. Erickson, Shell Oil Co., 5516 Glengarry Pkwy., Minneapolis 24, Minn.
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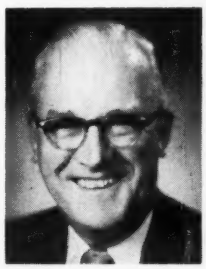

DEAN CLEAVELAND

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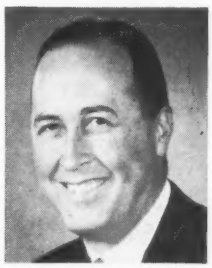

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A. B. TWO

D. W. SAWYER

ASLE News Notebook

Compiled by
R. D. McCormick

Executive Reports

Minutes of the January 9, 1957 Executive Committee Meeting were approved.

A new organizational plan which delineates the responsibilities and coordinates activities of the National Program Committee with the TAB and the technical committees, as well as that of the new Joint Industry Council, was presented to the Executive Committee. Basic approval of the plan was agreed upon, and the Committee authorized the preparation of the supporting literature in manual form to permit the manual's use by the Section Organizing Chairman and the various technical committees, as well as the Program Committee.

The auditor's report of cash receipts and disbursements for 1956 was presented. (The report is published in *Lubrication Engineering* elsewhere in this issue.)

Organization and Operations Committee

A proposed method of establishing an Industry Council within the Society structure was reported to the Executive Committee. Details of this change will be found elsewhere in this issue of the journal.

The following resolution, as amended by the Executive Committee, was presented to the Board of Directors at the April 17, 1957 Meeting.

BE IT RESOLVED, that there shall be established an ASLE research fund for the purpose of encouraging and providing financial assistance for the research necessary to solve basic technical problems directly affecting industry and the science of lubrication engineering. BE IT FURTHER RESOLVED, that a separate account or accounts be established on one or more recognized insured savings institutions in the name of ASLE Research Fund. Money accruing to the account of ASLE Research Fund shall be derived from the following sources:

1. A portion of the annual income from industrial membership fees.
2. A portion of the interest from all interest-bearing reserve accounts in savings institutions.
3. Grants and bequests from outside companies, organizations or individuals.
4. A portion of the excess of cash receipts over disbursements.
5. Such other sources of revenue as indicated by action of the Board of Directors.

Grants from said ASLE Research Fund are to be determined by a majority vote of the Board of Directors of ASLE upon the advice and recommendation of the Technical Advisory Board or Joint Industry Council. Administration of funds so approved as a grant by the Board of Directors shall be accomplished in the regular manner of disbursement by the Administrative Secretary.

The Technical Administration liaison of projects approved for grants from the ASLE Research Fund shall be vested in the Executive Committee of the Technical Advisory Board or Joint Industry Council through the Executive Committee member who sponsors the Technical Committee or Joint Industry Council which requested the project. Close contacts shall be maintained among the sponsor, the Committee, and the agency receiving the grant for the purpose of administration and reports of progress. This group shall have further responsibility of determining the feasibility of augmenting ASLE funds with outside funds from industry or other technical groups and of soliciting said funds.

Research projects to be considered for all grants from the ASLE Research Fund are to be proposed in detail by the technical committees and the industry councils to the Technical Advisory Board or Joint Industry Council which will recommend action to the Board of Directors through the Vice-President-At-Large.

Following an extensive discussion it was felt that further consideration of this resolution should be delayed until the Finance Committee and the O and O Committee has had an opportunity to present recommendations to the Board.

Appointments

J. O. McLean announced the following Director-Sponsor appointments for the 1957-58 year: S. R. Calish, Jr., By-Laws and Joint Lubrication Conference Committees; D. M. Cleaveland, Tellers, Nominations, and Finance Committees; J. H. Fuller, Awards and Education Committees; B. T. Harding, Membership & Admissions, New Sections, and Industrial Membership Committees; C. T. Lewis, Projects, and Journal Bearing Research Committees; D. W. Sawyer, Editorial, Abstracts, and Program Committees; A. B. Two, Industrial Relations, Industrial Advisory, and Handbook Advisory Committees; L. O. Witzenburg, Annual Meeting, Exhibit Arrangements, and Annual Meeting Sites Committees.

View of the registration area at the Sheraton-Cadillac Hotel during the first day of registration. Reports on the meeting indicate approval of the technical quality of the sessions, exhibits, and entertainment.

President McLean requested that Director-Sponsors forward to him their recommendations for Chairmen of the various committees in order that final appointments can be made prior to the June Board of Directors Meeting.

REGIONAL VICE-PRESIDENTS

CANADIAN — No report.

WESTERN

Attendance at the Los Angeles and Northern California Section Meetings has been good throughout the year. Average attendance at the Northern California Section has increased 60% over last year. At the 10th Anniversary Meeting of this Section in February, 95 persons were present. The Section paid respect to the memory of Mr. Wilbur L. Deutsch, who served as first Chairman of this Section.

Past-President Booser, accompanied by Regional Vice President (acting) A. C. West, visited the two existing Sections in the Western Region and participated in the initial Section Meetings in Seattle and Salt Lake City. An enthusiastic response was shown by both new groups.

Seattle area representative John Hood has been instrumental in founding the Puget Sound Section. Two well-attended meetings have been held. Current membership totals 25 individual members and two sectional sustaining memberships, and the new Section has submitted a petition for a Section Charter to the National Office.

The Western Rocky Mountain area representative Dudley Thomas has been instrumental in founding a section with headquarters at Salt Lake City to be known as the Intermountain Section. The new Section has over 20 individual members and two sectional sustaining members and has submitted a petition for a Section Charter to the National Headquarters.

Petitions from both Sections were approved, and plans have been made to present the Sections with their Charters sometime during President McLean's west coast tour.

EASTERN

With two exceptions, the entire Eastern Regional Sections have held education courses this year; in most cases with outstanding success.

Baltimore, Boston, New York, Philadelphia and others all had nearly or over 100 in attendance.

The Wheeling and Syracuse Sections did not present courses during this past year, but have indicated that they will conduct a lubrication train-

E. R. Booser (left) discusses some of the plans for the 1957-58 ASLE year with the newly elected Vice-President at Large J. D. Lykins.

George G. Spehn, of the Detroit Host Section, was a capable and humorous master of ceremonies at the Annual Meeting Banquet.

Membership Chairmen in most sections are working with real enthusiasm, usually with a planned program for membership. Total membership for the Eastern Region of ten sections totals 1,077. Estimated increase for the coming year is 254 new members.

Potential new sections are in the Huntington-Charleston, West Virginia and Rochester, New York areas. Potential sections may also be established in Washington, D. C., Birmingham, Alabama and the central Pennsylvania area.

Boston, Buffalo, Baltimore, Syracuse, New York and Philadelphia Sections were visited by the Eastern Regional Vice-President during the past year.

A proposal for a new type of section to be located in Washington, D. C. and composed solely of government employees dealing with the lubrication science was presented. Following a discussion of the proposal, it was referred to the Membership Committee for further investigation.

MIDWESTERN

Organization of the Dallas-Ft. Worth section by area representative F. A. Rudolph is in progress.

Approximately 16 pledged members for the Tri-Cities area in Moline-Rock Island-Davenport area have been reported by the area representative. An organizational meeting will be held as soon as 25 pledged members have been obtained.

Area representative F. J. Schmitt attended the March meeting of the Milwaukee Section. Approximately 60 members and guests were present.

Representatives from the ASLE Chicago Section met with representatives from the Chicago Section, Society of Automotive Engineers on April 9 to plan for a conference on automotive lubrication to be held March 11, 1958. A. B. Wilder was elected General Chairman of the Conference, and Robert M. Ladevich representing SAE was elected Vice-Chairman and Chairman of the technical sessions. This will be a joint venture between the two Sections, and will be publicized as a regional meeting sponsored by the two Chicago Sections representing ASLE and SAE. Attendance at the Conference is expected to reach between 500 and 600.

CENTRAL

Five of the nine sections in the Central Region were visited by the Regional Vice-President and the Executive Committee of the sixth was contacted.

Suggestions received during these visits have been reported to the National Office and acted upon to improve the effectiveness of the Society. Only the Kingsport Section (besides the Annual Meeting lubrication course held at Detroit), has sponsored a lubrication course. Possibilities for new sections in the Central Region during the coming year include the Akron-Canton, Ohio area; Grand Rapids, Michigan; and Birmingham, Alabama.

Toledo, Ohio, which should have interests sufficient to support a section, has shown no appreciable interest.

A recommendation received from T. Witt suggested the establishment of a Southern Region, and the election of a Regional Vice-President for the South.

This suggestion was referred to the Regional Vice-Presidents for study and recommendation to the Board of Directors.

TREASURER'S REPORT

Gross receipts through the opening day of the Annual Meeting totaled $7,653.00, plus $808.00 from the sale of preprints. Income from exhibits totaled $10,927.50. The total of 380 banquet tickets sold grossed $3,230.00, which deducted from the gross receipts indicated a total of $4,423.00 in receipts from registration.

ADMINISTRATIVE SECRETARY

Since January, extensive effort has been applied to straightening out deficiencies in the National Office records. Complete change-over has been made from the old membership record system to the new procedure, and a new method for notifying Section Secretaries of acquisitions, transfers and cancellation of membership has been completed. Communication ties between the National Office and the Sections have been strengthened as a result. Monthly membership reports are being sent to National Officers, Directors, Area Representatives and Section Officers. The report reflects a month by month accounting of membership, and in the future will probably be expanded to include statistics on membership for comparison with previous months or previous years.

Petitions from the Puget Sound and the Intermountain Sections have been received and accepted.

As of March 31, 1957, total membership in the Society was 2,888. This total does not include approximately 115 new applications pending. As of this date 444 members were in arrears. This represents 15% of our membership, and considerable effort should be expended by area representatives, Regional Vice-Presidents, and individual Section Officers so that this total can be reduced and these delinquent members salvaged. Each delinquent member has received three billings from the National Office.

Dick Booser receives a presidential citation from the ASLE Board of Directors at the banquet. Jim Hopkinson presents the citation acknowledging President Booser's outstanding service to the Society.

In the past two months approximately 2,000 membership brochures have been distributed to the Sections for promotional work.

The membership manual requires revision and the brochures treating sectional sustaining and industrial membership need to be rewritten. Although each of these items will require a considerable amount of staff time and money, they are deemed desirable for a good membership promotion program.

In the near future a monthly newsletter will be sent to National Officers, Directors, Vice-Presidents, Area Representatives and Section Chairmen to assist in solving the problem of communication between the National Office and Sections. The newsletter will contain various types of information on membership, new sections, new procedures and other information of interest to Section operations. Experiences of the Sections will be solicited on such subjects as membership programs, effective meetings, speakers, and program planning.

An agreement has been reached with the firm of McDonald-Thompson to handle the advertising in the West Coast area for *LUBRICATION ENGINEERING*. This firm will represent the journal in soliciting advertising space from the 15 western States, including British Columbia. Promotional material covering the journal, its market, the buying powers of the Society's members, identification and job descriptions, plus company affiliation of the members, will be required for the promotional use of this firm. These are requirements in addition to circulation statement, rate cards, and mechanical requirements as required for the sale of advertising. Considerable portion of staff time will be required to prepare this material.

Dudley D. Fuller receives the Society's highest award—The ASLE National Award for his contributions to education in lubrication engineering and for numerous contributions to the literature.

Annual Meeting Awards Presentation
J. H. Fuller, Chairman
Awards Committee

"Mr. President, Ladies and Gentlemen, we appreciate the privilege of announcing the Annual Awards of the Society.

"The WALTER D. HODSON AWARD is made to a member of our Society of thirty years of age or less for a paper presented or published within our Society on lubrication or an allied subject. The Awards Committee has selected the paper *The Equilibrium Distribution of Transfer Fragments* by E. Rabinowicz as the outstanding paper in this category. Mr. Rabinowicz was unable to be here tonight.

"The next award is the CAPTAIN ALFRED E. HUNT MEMORIAL AWARD which is made to a member of ASLE for single authorship of an outstanding paper on lubrication presented to the Society. The author selected this year is Douglas Godfrey for his paper *A Study of Fretting Wear in Mineral Oil*. Mr. Godfrey, will you please come forward.

"Last year the Board of Directors created the WILBUR DEUTSCH MEMORIAL AWARD in memory of Mr. Deutsch, our 1956 President, whose untimely death last year shocked us all. This Award is in recognition of ASLE members who present papers on the practical aspects of lubrication. One of Mr. Deutsch's main interests in ALSE was the ability of the society to provide information to the engineer in the plant who must solve his own problems daily. This year the Award's Committee felt that no paper presented before the Society met the requirements of this award. We feel sure that this award will offer a goal to ASLE members qualified to provide papers to the Society of a practical nature and of great value to our membership.

"The ASLE NATIONAL AWARD, highest award of the Society, is made in recognition of outstanding contributions to the field of lubrication engineering. This award provides honorary life membership in the Society. We take great honor in announcing that the recipient of this award this year is Dudley D. Fuller."

Past President E. R. Booser presents the Captain Alfred E. Hunt medal to Douglas Godfrey for the year's outstanding paper in the field of lubrication.

Ernest Rabinowicz received the Walter D. Hodson Award for the year's best paper authored by a Society Member 30 years of age or less.

In The Next Issue!

At the June Board of Directors Meeting a revision in the structure of the publishing activities was approved. A special report will describe how the new organization will assist in expanded editorial activity for the journal and how increased emphasis on information treating plant and field problems and solutions will be published.

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the American Society of Lubrication Engineers is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

Members: Members shall be persons not less than 24 years of age who: (1) are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibilty for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, and have manifested a particular interest in the purposes and welfare of the Society to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee $15.00.

Associate Members: Associate Members shall be persons less than 24 years of age, and those who do not completely fulfill the membership requirements for Members. Fee $7.50.

Sectional Sustaining Members: are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

Industrial Members: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

For application blanks or further information, write:

ASLE
84 E. Randolph St.
Chicago 1, Ill.

AMERICAN SOCIETY OF

Statement of Cash Receipts and Disbursements

Year Ended December 31, 1956

RECEIPTS		
Membership Dues		$44,855.65
Subscriptions and Sales of Publications		8,827.07
Exhibit Funds —		
1956 Show collected in 1955, transferred to free surplus in 1956	$ 5,005.00	
1956 Show collected in 1956	4,905.00	9,910.00
Annual Meeting —		
Guest registration and banquet tickets	$ 7,031.50	
Lubrication Engineering Course	1,312.50	8,344.00
Advertising Income		24,682.45
Interest and Sundry Income		1,054.64
TOTAL		$97,673.81
DISBURSEMENTS:		
Salaries, commissions, fees		$34,039.87
Cost of publications		26,291.71
Office furniture and equipment purchases		3,668.89
Office supplies and expense		877.30
Railroad fares and travel		2,829.62
Section payments		7,874.40
Rent		2,740.00
Telephone and telegraph		1,618.63
Dues, donations and subscriptions		436.27
Legal and auditing expense		450.00
Federal insurance contributions and unemployment tax		885.48
Sundry merchandise purchases		360.95
Payment for journal bearing research		611.29
Annual meeting expense		7,547.52
Awards expense		103.00
Exhibit expense —		
1956 show paid in 1955	$ 615.74	
1956 show paid in 1956	1,339.91	1,955.65
Postage and express		1,587.56
Stationery and printing (excluding Exhibit costs)		2,332.20
Group and other insurance		499.33
Educational program		300.00
Joint conference expenses		311.46
Directors' and committees meeting expenses		523.80
Contingencies		178.95
Personnel service fees		532.80
Total		$98,556.68
Excess of disbursements over receipts*, representing net decrease in free surplus during year ended December 31, 1956		$ 882.87

**During the year* $3,668.89 *was expended for office equipment primarily for producing preprints and for membership records. After deducting* $674.09 *for depreciation, the surplus invested in furniture and equipment increased in the amount of* $2,994.80 *to* $6,130.57.

Coming Events

JUNE 17-20, Institute of Aeronautical Sciences (Annual Summer Meeting), Biltmore Hotel, Los Angeles, Calif.

17-21, American Society for Engineering Education (Annual Meeting), Cornell Univ., Ithaca, N. Y.

17-21, American Society for Testing Materials (60th Annual Meeting), Chalfonte-Haddon Hall, Atlantic City, N. J.

19-21, 1957 Heat Transfer & Fluid Mechanics Institute, Calif. Inst. of Tech., Pasadena, Calif.

20-22, American Physical Society (Regional Meeting), Notre Dame, Ind.

23-28, National Association of Power Engineers (National Convention), Pantlind Hotel, Grand Rapids, Mich.

JULY 28 thru August 9, Columbia University, Dept. of Industrial & Management Engineering (Utility Management Workshop), Arden House, Harriman, N. Y.

AUGUST 11-15, American Society of

LUBRICATION ENGINEERS

Balance Sheet - December 31, 1956

ASSETS

WORKING CAPITAL ASSETS:		
Cash on deposit and on hand —		
Bank checking account	$ 390.80	
Bank savings account	124.62	
Petty cash fund	35.00	
Total working capital assets		$ 550.42
RESERVE FUND ASSET:		
Savings and Loan Deposits	$34,569.35	
Investment in United States Treasury Bonds — at cost	14,709.11	
	$49,278.46	
Less: Short term loan obtained December 12, 1956 from one of the above depositories	2,000.00	47,278.46
OFFICE FURNITURE AND EQUIPMENT:		
At cost	$ 8,575.39	
Less: Allowance for depreciation	2,444.82	
Net book value		6,130.57
		$53,959.45

LIABILITIES AND SURPLUS

LIABILITIES:		
Account payable as trustee — award fund contributed by W. D. Hodson, Jr.	$ 25.00	
Account payable — payroll withholding taxes	498.30	
Total liabilities		$ 523.30
SURPLUS:		
Surplus reserve — Unearned rentals collected during 1956 for 1957 Exhibit	$ 4,958.60	
Free Surplus	42,346.98	
Surplus invested in office furniture and equipment	6,130.57	
		53,436.15
		$53,959.45

NOTE: *The above statement has been prepared on the basis of cash receipts and disbursements.*

THE ABOVE REPORT IS IN AGREEMENT WITH THE AUDITORS' REPORT AS PREPARED BY C. L. GRIMES & CO. CERTIFIED PUBLIC ACCOUNTANTS.

Mechanical Engineers (Heat Transfer Conference), Pennsylvania State Univ., University Park, Pa.

SEPTEMBER 5-7, American Physical Society (Regional Meeting), Boulder, Colo.

8-13, American Chemical Society (National Meeting), New York City.

9-12, Society of Automotive Engineers (Tractor Meeting & Production Forum), Hotel Schroeder, Milwaukee, Wisc.

9-13, American Society of Mechanical Engineers (Instruments & Industrial Regulators Div., Joint Conference & Exhibit with Instrument Society of America), Auditorium, Cleveland, Ohio.

9-13, Instrument Society of America (12th Annual Instrument-Automation Conference & Exhibit), Auditorium, Cleveland, Ohio.

10-13, American Statistical Association (Annual Meeting of Section on Physical & Engineering Sciences), Atlantic City, N. J.

15-18, American Institute of Chemical Engineers (Regional Meeting), Lord Baltimore Hotel, Baltimore, Md.

22-25, American Society of Mechanical Engineers (Petroleum Mechanical Engineering Conference), Mayo Hotel, Tulsa, Okla.

23-25, American Society of Mechanical Engineers (Fall Meeting), Statler Hotel, Hartford, Conn.

23-25, Standards Engineers Society (6th Annual Convention), Commodore Hotel, New York City.

23-26, Association of Iron & Steel Engineers (Annual Convention), Penn Sheraton Hotel, Pittsburgh, Pa.

24-25, Institute of Radio Engineers, and American Institute of Electrical Engineers (Industrial Electronics Conference), Morrison Hotel, Chicago, Ill.

30 thru October 2, American Oil Chemists' Society (Fall Meeting), Netherland Hilton Hotel, Cincinnati, Ohio.

OCTOBER 1-5, Society of Automotive Engineers (Aeronautic Meeting, Aircraft Production Forum & Aircraft Engineering Display), Ambassador Hotel, Los Angeles, Calif.

6-9, American Institute of Mining, Metallurgical & Petroleum Engineers (Petroleum Branch Meeting), Dallas, Tex.

6-10, Electrochemical Society (112th Meeting), Statler Hotel, Buffalo, N. Y.

7-9, ASLE-ASME 4th Annual Lubrication Conference, Royal York Hotel, Toronto, Canada.

7-9, National Electronics Conference, Sherman Hotel, Chicago, Ill.

7-11, Society of Photographic Scientists & Engineers (National Conference), Berkley-Cartarette Hotel, Asbury Park, N. J.

10-11, Armour Research Foundation (National Noise Abatement Symposium), Sherman Hotel, Chicago, Ill.

10-12, American Society of Mechanical Engineers (Fuels Conference), Chateau Frontenac, Quebec City, Canada.

14-18, American Society of Civil Engineers (National Convention), Statler Hotel, New York City.

14-18, Stanford Research Institute, and Time-Life International (International Industrial Development Conference), Fairmont Hotel, San Francisco, Calif.

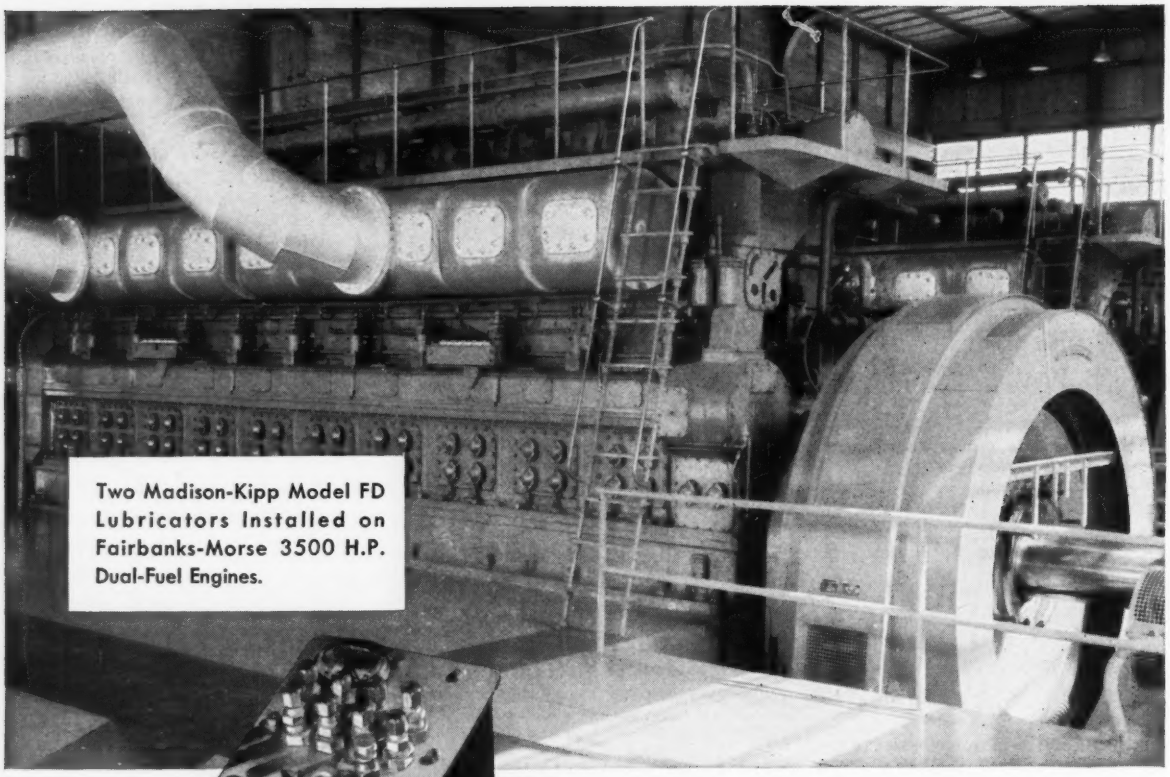
PERSONALS

Irving Pollock has been transferred to the Houston, Texas office of The Texas Co., where he will be in charge of technical service activities for their Southern Region.

E. G. Bennett, Eastern Regional Manager, E. I. duPont de Nemours & Co. has been transferred to the New York office.

Robert L. May has been transferred from the Sinclair Research Laboratories, Harvey, Illinois, to the New York office, where he will be Assistant Refining Manager.

Briggs Filtration Co., Chicago, Ill. has announced the promotion of **John MacGuffin** to Sales Manager. He will be located at the company's Washington, D. C. plant.



Two Madison-Kipp Model FD Lubricators Installed on Fairbanks-Morse 3500 H.P. Dual-Fuel Engines.

Machines of great performance use the most dependable oiling system ever developed

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Fresh Oil

...by the measured drop, from a Madison-Kipp Lubricator is the most dependable method of lubrication ever developed. It is applied as original equipment on America's finest machine tools, work engines and compressors. You will definitely increase your production potential for years to come by specifying Madison-Kipp on all new machines you buy, where oil under pressure fed drop by drop can be installed. There are 6 models to meet almost every installation requirement.

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Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Lube Lines

by A. F. Brewer*

TIMING

Research pertaining to the benefits of timing in labor and machine operations dates back some 75 years. It began with the studies of Frederick W. Taylor who has justifiably been regarded as the father of modern time study as related to mass production. By application of his thesis, it was developed that a definite relation prevails between the timing of production methods and the resultant output of machines. This contributes to conservation of labor efforts, elimination of unnecessary work, reduction of material waste, and speed-up of manufacture. The modern production line is tangible evidence of the soundness of Mr. Taylor's thinking.

More recently, lubrication people have realized the need for timing in the lubrication of production machinery. It is a procedure which can be taken care of manually or automatically. In reality, timed lubrication has prevailed ever since the days of the "tallow pot." A shot of oil or a turn on a grease cup every so often when the operator thought necessary was, in effect, timed lubrication. Unfortunately, the time intervals were not always spaced according to the needs of the operating parts, and in view of the usually ineffectual sealing methods which prevailed in those days, a considerable amount of lubricant might have leaked out before the operator got around to relubricate.

AUTOMATIC LUBRICATION

Where completely automatic lubrication is involved, timing is built into the system. Here the designers provide for delivery of oil or grease in adequate amounts to avoid any possibility of starved lubrication. The essence of the idea is the right amount in the right place at the right time. In a mechanically controlled system, a factor of safety can be included which provides for just a little more than the right amount, to be on the safe side. Unless this is carried out to such an extent as to force lubricant out past the seals, it is good preventive insurance.

Timing and the lubrication schedule go hand-in-hand. The latter requires study of the machine: just how well its operating parts are housed or protected to enable retention of lubricants, the prevailing operating speed and temperature ranges, the type of seals and their ability to prevent lubricant contamination, and to what extent an oil can serve as a flushing medium.

Naturally, records of plant production, maintenance costs, and lubricant consumption are essential to working out an effectual lubrication schedule in anticipation of setting up a time table. Operating experience, of course, is valuable; also important is a thorough knowledge of the potential lubricating abilities of any or all lubricants to be considered.

In connection with lubricating ability, it will be well for the plant lubrication people to consult with the lubrication engineering personnel of the petroleum as well as the chemical industries. These authorities have had extensive experience with a wide variety of production and operating conditions; they are fully conversant with the limitations of petroleum base lubricants as compared with solid and synthetic chemical materials, and they are familiar with the range of usefulness of the proprietary lubricating systems available.

LUBRICATION, NOT LUBRICANTS

Wherever it is practicable to develop and apply a system of automatic lubrication which is correctly timed as to delivery of lubricants, the elimination of the human element is a boon to the operating and maintenance people. They can utilize available man-power in plant service far more effectually than when it may be required for clean up of dripped lubricants. Then, the plant lubrication engineer can become a consultant to the management, purchasing, operating, and maintenance departments. Then, the maximum of lubricating value is obtained from the most suitable lubricants; fire hazard is reduced, and the cost of lubrication per unit of production materials can be established. It all sums up to the wisdom of following the modern concept of buying lubrication, not just lubricants, and seeing that it is properly maintained.

The potential value of timed lubrication as compared with manual handling of lubricating equipment, can be developed by recording time requirements and volume of lubricants (on a monthly basis) according to the accompanying chart.

	Method of Lubrication	
	By Manual Application	By Automatic Timed Application
Manhours for Lubrication		*
Down-time for Maintenance or Repair		
Volume of Lubricants Required, monthly		
*Filling Lubricators		

*Consultant, and Author of *Basic Lubrication Practice.*

THE BROOKS OIL CO.

Lub-Engineering News

A REPORT ON THE DIFFICULT LUBRICATING PROBLEMS OF INDUSTRY

93% SAVING IN MILL TABLE LUBRICATION COSTS REPORTED BY LEADING STEEL PRODUCER

A leading steel producer recently went through a series of corrective measures to improve lubrication of mill tables. They went from circulating oil system to pressure grease system and finally to automatic spray system.

In the spray system, they used Brooks Klingfast and reported a saving of 93% in lubricant cost. They do not attribute the saving to the change in equipment, as various lubricants were tested. Klingfast offered the greatest reduction in lubricant cost for the application.

Records indicate a 35% decrease in man hours spent on this lubrication job, and 65% less maintenance delays due to improved lubrication. Klingfast has proved itself against adverse conditions of mill scale, water and high temperatures. Savings in maintenance costs were coupled with increased production.

For full information, write for Engineering Letter 73LE.

NEW COLOR FILM AVAILABLE TO LUBE-ENGINEERING GROUPS

This new 30 minute 16 mm motion picture, in full color, with sound, shows a number of tough lubrication jobs. It pictures and describes the research, manufacturing and quality control methods that enable Brooks lubricants to "stand up" under severest service.

It's available to any supervisory or engineering group interested in lubrication problems. No charge, of course — we're glad to have you see it. Just call or write any of our offices and tell them you want to borrow "The Brooks Oil Story."

CIRCULATING OIL SYSTEMS REQUIRE LUBRICANTS THAT WITHSTAND SEVERE STCONDITIONS

Dust, dirt, water and metallic contamination present extremely difficult problems for circulating oil system lubricants — in steel mills, forging and press shops, cement plants and many other industries. Lubricating compounds must withstand constant contact with contamination, readily dissipate such foreign matter and maintain quality for continued service.

Brooks Leadolene and Klingfast are compounded to meet such severe conditions. These products have served industry for more than a quarter of a century and have broken many records. Companies in the United States and Canada have obtained 5, 10, 15 and 20 years of continued service from these lubricants. For complete facts, see your Brooks representative or write for Engineering Letter 86LE.

THE BROOKS OIL CO. 81st YEAR 1876 1957

THE BROOKS OIL COMPANY

EXECUTIVE OFFICES AND PLANT—CLEVELAND, OHIO

EXECUTIVE SALES OFFICES—928 RIDGE AVENUE, PITTSBURGH 12, PA.

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CUBA-S.A.
EUROPE

Section News

Baltimore

APRIL. On April 25, the Baltimore Section toured the Esso Standard Oil Co. Bulk Station. MAY 31 was the Annual Banquet & Dance and included ladies' night. Dancing was held and new officers were installed (see Directory.)

Boston

APRIL 24. Mr. B. M. Dunham, of the Sun Oil Co. spoke on "Paper Mill Lubrication." MAY 20, Past Chairman's Night. Demonstration and Movies by the Ethyl Corporation on "Fire Power."

Chicago

APRIL 11. Mr. G. E. Evans of the Penola Oil Co. spoke on "Additives." New Section Officers were elected. (See Personals and Directory.) MAY 16. Final meeting of the season. Mr. R. A. Swenson of the Standard Oil Co. (Indiana) spoke on "Lubricating Greases & Extreme Pressure Properties." JUNE 20. The Chicago Section Annual Golf Party will be held at the Cog Hill Golf Course. Tee-off time 9:00 A.M.

J. N. WADDELL

The Chicago Section, ASLE, have elected J. N. Waddell of the Henry H. Cross Co. as Chairman for the 1957-58 year. Also elected were: E. W. Drummond, International Harvester Co., Vice-Chairman and G. S. Metcalfe, The Farval Corp., Secretary-Treasurer.

Central Ohio

APRIL. Professor P. H. Black of Ohio University spoke on "The Mechanics of Lubrication in Bearings, Gears, and Metal Cutting."

Cleveland

APRIL 23. Mr. J. R. McCoy, Indiana Commercial Filters Corporation, spoke on "Filtration of Industrial and Lubricating Oils." MAY 28. "Stump the Experts Night." A panel of experts was chosen from the members and guests present to answer questions and problems posed by the audience. Prizes were awarded for each question not answered satisfactorily by the panel.

Duluth — Iron Range

APRIL 24. Mr. J. M. Miller, Standard Oil Co. (Indiana), spoke on automotive "Look Ahead," which covered automotive manufacturers service research, future lubricants, multigrade viscosity, and gas turbines. Officers for next year were nominated.

Houston

MAY 6. "Keeping the Wheels Turning" was the subject of a talk by Mr. W. A. Illg, Assistant Chief Engineer for Link Belt Co. in Houston. Antifriction bearing lubrication and maintenance were covered by the speaker in the last meeting prior to resuming meetings of the Section in September.

Los Angeles

MAY 8. "Fundamentals and Laboratory Evaluation of Cutting Fluids" was presented by Mr. L. H. Sudholz of the Socony Mobil Oil Co. The speaker emphasized the fundamentals of the metal cutting process, nature of the lubricating problem, effect of cutting fluids, and the evaluation of cutting fluids. The roles of fluids and their additives in combating extreme pressures and temperatures and their relationship to tool life were discussed.

Milwaukee

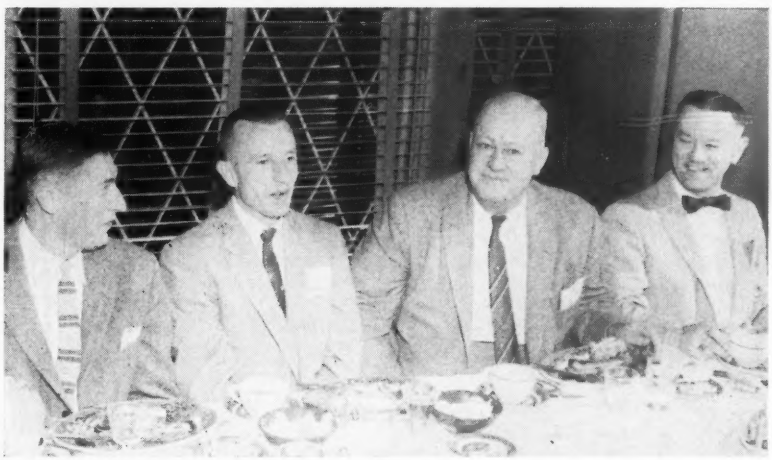
APRIL 18. Following a movie, "Taconite Processing," Mr. J. R. McCoy, Manager, Technical Service, Indiana Commercial Filter Corporation, spoke on "Filtration of Industrial & Lubricating Oils." MAY 18. Annual Ladies' Night Dinner Party. Entertainment was provided by the Schlitz Sextette and a door prize of matched earrings and pendant was awarded. C. L. Willey, Administrative Secretary of ASLE and Dr. A. B. Wilder, Midwestern Regional Vice President, were guests at the meeting.

Northern California

MAY 9. Mr. L. H. Sudholz, Socony Mobil Oil Co., Inc. spoke on "Fundamentals and Laboratory Evaluation of Cutting Fluids." JUNE 7. Fifth Annual Dinner Dance at the Alameda Naval Air Station Officers' Club.

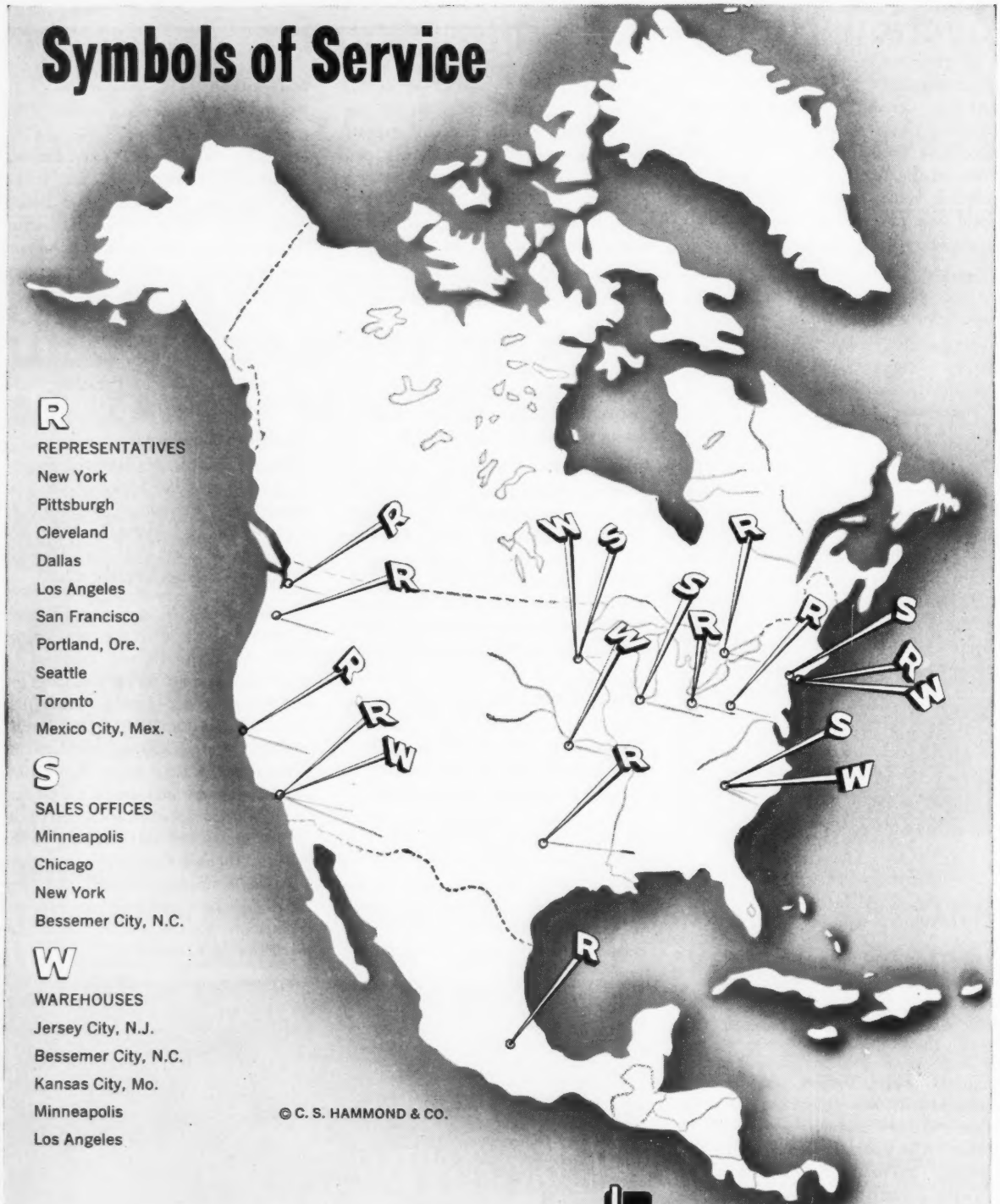
Twin Cities

APRIL 25. An afternoon tour of the lube oil manufacturing facilities of Farmers Union Central Exchange in St. Paul preceded dinner. After dinner, the Section toured the grease manufacturing facilities of Metalcote Grease & Oil Co. MAY 23. Ladies' Night. Dinner and dancing were featured, and, as a special attraction to the ladies, Miss Dorothy Cederberg of the Oil Information Committee, American Petroleum Institute, lectured and demonstrated how oil and oil products contribute to the comfort and convenience of woman's life.



Shown at the Milwaukee Section Ladies Night held in May are (left to right) James Gramling, retiring chairman; C. L. Willey, ASLE Administrative Secretary; A. B. Wilder, Midwestern Regional Vice President; and Milt Bates, newly elected Section Chairman. (Photo by Roy Plumb, Milwaukee Section.)

Symbols of Service



. . . trends ahead in industrial applications for lithium

LCA

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PROCESSORS OF LITHIUM METAL • METAL DISPERSIONS
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SALTS: Bromide • Carbonate • Chloride • Hydroxide • Nitrate
SPECIAL COMPOUNDS: Aluminate • Borate • Borosilicate • Cobaltite • Manganite
Molybdate • Silicate • Titanate • Zirconate • Zirconium Silicate

BRANCH SALES OFFICES: New York • Chicago • Bessemer City, N. C.
MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, N. C.
Cat Lake, Manitoba • Amos Area, Quebec
PLANTS: St. Louis Park, Minnesota • Bessemer City, N. C.
RESEARCH LABORATORY: St. Louis Park, Minnesota

Yield Stress as a Factor in the Performance of Greases

An apparatus is described for measuring the cone resistance value of a grease as a function of temperature. This value is related theoretically to the yield stress of the grease. Results show that, for a given bearing, if the yield stress of the grease falls below a critical value as a result of the bearing temperature rise, continuous churning of the grease occurs with the production of excessive heat. It is also shown that the dispensability of a grease from a container by pumping can also be calculated from the yield stress. It is concluded that the cone resistance value, particularly when measured as a function of temperature, is a useful property for defining the quality of a grease.

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INTRODUCTION

The standard penetration tests for greases are often criticized on the grounds that penetration is a complex function of yield stress and viscosity, and the contributions to performance of these two rheological components will hardly ever appear in the same relationship as they do in the penetration test. It follows that the measurement of these two properties separately would offer data of more significance than penetration values. The viscosity of a grease can be measured in a number of ways, each giving the same result provided certain precautions are taken. On the other hand, yield stress must be arbitrarily defined, and the different definitions and methods of measuring result in values which vary considerably. We have chosen to measure yield stress with a cone indentation test, carried out under carefully controlled conditions. The parameter measured in this test is called the Cone Resistance Value (C.R.V.) which, for an ideal material, is related by a numerical constant to the yield stress.

In attempting to correlate yield stress, or C.R.V., to the behaviour of greases in service, it is essential to carry out measurements at temperatures which obtain in the particular application. Consequently, an apparatus has been designed and built to measure C.R.V. over a fairly wide temperature range.

The apparatus has been applied to two problems. Thus, in a widely used large-bore roller bearing which possesses a large-capacity cover plate, the proper functioning of the bearing requires the grease to support itself against slumping. On the other hand, in dispensing grease from containers by means of a pump, the proper functioning of the pump requires the grease to slump readily. In both these applications the slumping characteristics of the grease are shown to be a function of the C.R.V. at the operative temperatures.

THEORETICAL

The Measurement of Yield Stress

In general, a grease does not possess a sharp yield stress marking the boundary between conditions of flow and no-flow. Therefore, following Scott-Blair,[1] the yield stress may be taken to be that shear stress at which the flow curve (rate of shear plotted against shear stress) suffers a rapid change in slope. The curves presented by Amner, Blott, and Dawtrey,[2] plotted as log (apparent viscosity) against log (rate of shear) show more than one discontinuity; and some recent experiments carried out with a parallel plate plastometer[3] indicate that a further discontinuity occurs at shear stresses lower than the range covered in earlier work. At very low shear stresses, a grease undergoes a permanent (viscous) deformation in addition to a reversible (elastic) deformation. The rate of permanent strain varies with stress according to the Newtonian law, and for N.L.G.I. grade 3 greases in the temperature range 25 to 50°C., the corresponding viscosity is of the order of 10^{11} poises. Consequently, a complete flow curve of a grease will be of the form shown in Figure 1.

The shear stress at A is a yield stress, which corresponds in practice to a boundary between flow and no-

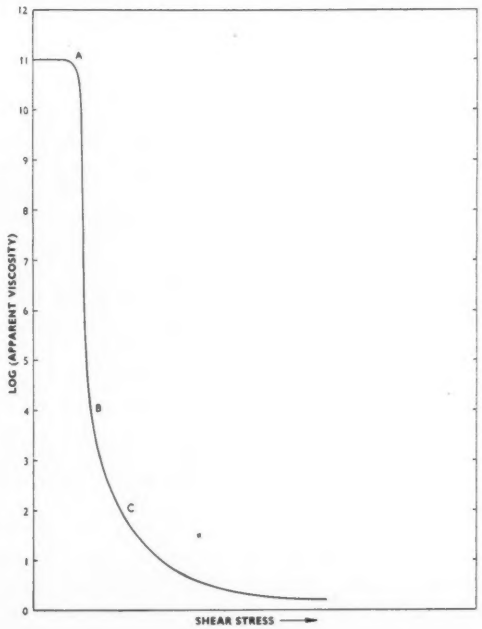

Figure 1. General form of flow curve of a grease.

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flow, since a viscosity of 10^{11} poises means that the grease is virtually at rest. On the other hand, the yield stresses on the Amner-Blott-Dawtrey flow curves come between points B and C and correspond to flow rates which are relatively large. In yield stress determinations on greases, use is often made of the Bingham equation which applies only approximately. Values of yield stress obtained by extrapolations according to the Bingham equation depend on the part of the flow curve which is measured and can be higher than the stress at point C. The method to be described can be shown, by an analysis which will be published elsewhere, to give a measure of yield stress in the steeply ascending region near point A (Figure 1).

The basis of the test method is the cone indentation test, which was discussed by Alexander and Blott[4] for testing road-making materials, and was later considered by the Rheological Tests Panel of the Institute of Petroleum[5] as an alternative to the standard grease penetration method. In this test, the bearing capacity p, or in other words the Cone Resistance Value *C.R.V.*, is calculated from the net load supported by the grease. We have:

$$p = C.R.V. = (L\text{-}B)/A \qquad [1]$$

where L is the load on the cone, B is the buoyancy, and A is the cross-sectional area of the cone in the plane of the grease surface (neglecting effects due to the rise of the grease surface). The relationship between p and yield stress τ_o has not been worked out for a cone indenter, but various workers, including Prandtl[6] and Hill[7] have calculated the two-dimensional problem of a wedge pressed into an ideal plastic rigid material. For a 90° wedge angle, two limiting cases are obtained:

$$p = \tau_o\,(2 + \pi/2) = 3.57\,\tau_o \qquad [2]$$

and $$p = \tau_o\,(2 + \pi) = 5.14\,\tau_o \qquad [3]$$

Equation [2] refers to complete slipping between wedge and the test material, while Equation [3] refers to the condition of no slip. We assume that a similar simple relationship holds for a 90° cone, but the value of the constant of proportionality a will depend on the differences due to the third dimension and the degree of slip.

$$p = a\tau_o \qquad [4]$$

Application of this general test procedure to greases necessitates the fixing of an arbitrary time interval to define when the cone has come to "rest." Experiment has shown that five minutes is a period not too long from the point of view of speed of testing, and yet is sufficiently long for the rate of movement of the cone to become small, although remaining finite. Because true equilibrium is not attained, τ_o calculated from C.R.V. is always too high. The many uncertainties attached to the meaning and evaluation of τ_o make it undesirable to calculate it, and therefore test results are normally given in units of C.R.V.

The chief differences between the test adopted in the present work and the tests used in earlier work are that in the new test, the depth of penetration of the cone is fixed within narrow limits, and the cone is lowered slowly into the grease. These important conditions, together with the fixed period of floating, ensure that all greases are tested at the same average rate of shear corresponding to a value close to that represented by point A in Figure 1, and that all greases suffer the same amount of shear. Since the rheological behaviour of greases depends on both rate and amount of shear, the new test conditions are necessary and sufficient for a significant comparison of greases.

EXPERIMENTAL

Apparatus Requirements

A 90° right circular cone is used which should be as light as possible when dealing with soft greases. By using duralumin for a cone 15 mm. high and stainless steel hypodermic tubing for the shaft, a cone assembly weighing about 6 g. can be made. Circular slotted weights, which sit on the upturned base of the cone, are required for load adjustment.

The sample containers must be large enough so that wall effects are excluded, the criterion being that the slip planes at the equilibrium floating position of the cone must not cut the walls. According to Prandtl's theory, this condition is met if the cup diameter is greater than six times the depth of penetration, and the cup depth is greater than $\sqrt{2}$ times the depth of penetration.

An arrangement is required for lowering the cone assembly into the grease at a slow, fairly constant rate, and when the cone is floating, the frictional drag from the guide holding it vertical must be a minimum. The depth of penetration must be measurable to within 0.1 mm., and provision for carrying out replicate tests at various temperatures is desirable.

These requirements can be met by quite simple equipment, but for general use the following apparatus has been designed and made.

The Multiple-sample Apparatus

Photographs of the apparatus are shown in Plates I, II, and III. It comprises two hollow brass chambers, turned from the solid to eliminate joints as much as possible, which form the constant temperature vapour bath. The upper chamber (Plate II) has a central hole which fits over a chimney projecting from the lower one. Holes in this chimney provide a connection between the hollow chambers, and Neoprene O-rings make the joint liquid and vapour tight. Each chamber contains a 1500 watt strip heater (connected to the mains via a variable transformer) which rapidly brings the chosen liquid to its boiling point and then maintains a constant temperature over long periods of time. Both chambers are thermally lagged.

The chromium-plated top surface of the lower chamber contains four cylindrical depressions as grease cups, 6

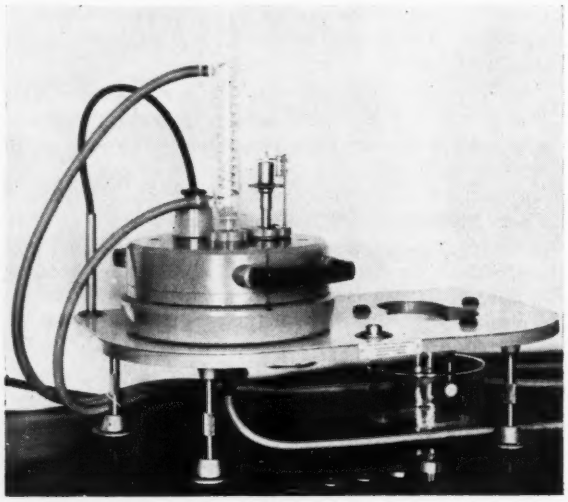

Plate I. General view of apparatus.

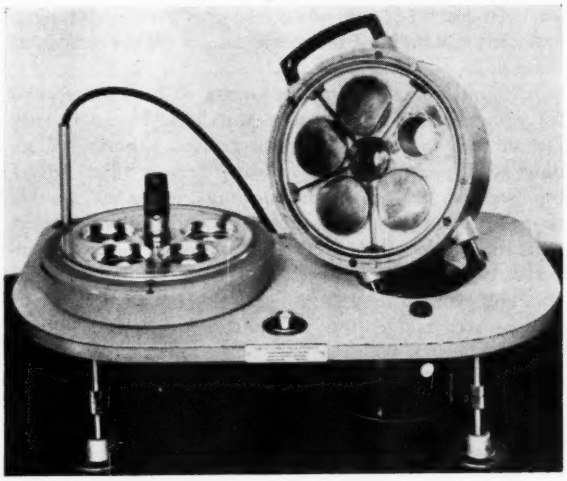

Plate II. Apparatus opened up.

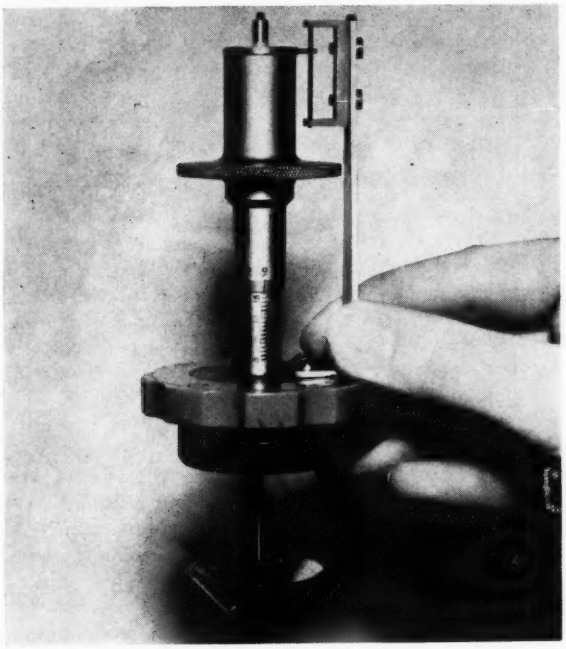

Plate III. Cone assembly

cm. dia. × 1.5 cm. deep. The plated bottom surface of the upper chamber is dished to accommodate four metal pads, which correspond with the four cups, and a gap of about 1 mm. between the surface of the lower chamber and the surfaces of the pads. Between each pad is a flat spring-loaded scraper which, on rotation about the central chimney, removes excess grease from the cups and leaves a levelled surface. Clearly, the top surface of the lower chamber forms a convenient zero plane, or reference surface, for the penetration measurement.

The upper chamber also contains a hole centered on the same diameter as the centers of the cups and pads. Into this hole the cone assembly can be quickly placed in position and held by a ring-shaped spring. The cone assembly, shown in Plate III, comprises a duralumin 90° cone and a 6-inch length of stainless steel hypodermic tube, carrying a small flat plate at its upper end, and a hollow micrometer. Two spaced guide-holes are provided in the micrometer. Normally, the plate carrying the cone rests on the top of the micrometer; on rotating the micrometer barrel, the cone is then lowered (or raised), a wire projection on the plate preventing the cone itself from rotating. When the cone, by touching the reference surface or by floating in the grease, is impeded, a gap opens up between the plate and micrometer top. By just closing this gap the micrometer reading then corresponds to the position of the cone tip. This adjustment is very easily and precisely made and can be reproduced to within 0.02 mm.

Test Method

The grease is worked 60 strokes in the standard grease worker and transferred to the sample cups so that each cup is slightly overfilled. The upper chamber is put on, and the chosen liquid is poured in, to just cover the upper heater. The cone assembly is mounted, a condenser is fitted, the electrical connections are made, and heating is started. Experience has shown that the C.R.V. of most greases increases with time at a given elevated temperature, but that after two hours the rate of change is very small. Therefore, although the apparatus will bring the four samples to the required temperature in less than ½ hour, it is necessary to wait for 2 hr. before commencing the readings. Otherwise, the values would increase from the first to the fourth samples. This period of rest, particularly at higher temperatures, causes the samples to approach the unworked condition.

The zero reading of the cone can be taken when the upper chamber is in the "Heat" position, i.e. when the heating pads are over their corresponding cups. To continue the test, the upper chamber is rotated to the first "click" stop; when the scrapers have levelled the grease surfaces, the cone assembly will be positioned over the first grease cup (as in Plate I). The cone is lowered at a rate of 0.5 mm. per second (or more slowly) until the plate separates from the top of the micrometer, at which point the cone starts to float. After 5 minutes floating time, the new position of the cone is measured. The cone is quickly removed, cleaned and replaced, and the measurements repeated on the other samples.

The depth of penetration is maintained between 7.5 and 8.5 mm. by suitably adjusting the load on the cone. Thus, if in the first test the penetration is outside these limits, the load is changed accordingly for the next test. An experienced operator requires no more than one trial to decide on the correct load. Over the fixed range of penetration, the value of C.R.V. changes by less than one unit of C.R.V.

The results are calculated with no correction for the rise in grease level, which is nearly constant for all experiments, from the equation:

$$C.R.V. = \frac{L - \pi d^3 \rho / 3}{\pi d^2} \quad g./cm.^2 \qquad [5]$$

where L is the load, d is the penetration in cm., and ρ is the specific gravity of the grease which is assumed to be 0.95 g./cc. The C.R.V. at a given temperature is the mean of at least two determinations.

To obtain a C.R.V./temperature curve, tests are carried out at room temperature, 56°C. (using acetone), 78°C. (using I.M.S.), and 100°C. (using water). Lower temperatures are conveniently included by carrying out tests in a cold room.

Repeatability

For values of C.R.V. up to about 100 g./cm.², duplicate tests should not differ by more than 2.3 units (95% probability).

RESULTS

Comparison of C.R.V. Test with Penetration Test

Because the standard A.S.T.M., or I.P., penetration contains a component of yield stress, it is to be expected that the C.R.V. and penetration of grease should correlate approximately. That is, over a wide range of consistency as the penetration increases, so the C.R.V. at the same temperature should decrease. Figure 2, which is a plot of I.P. penetration against C.R.V. at the same temperature, shows that this is the case. However, the correlation is not good, especially within the narrow range of consistency encompassing a single N.L.G.I. grade.

Application of the C.R.V. Test

It has already been mentioned that the yield stress or C.R.V. of a grease will be a significant parameter in applications where the grease receives little support from its container. In some applications, the grease is required to remain stationary; while in others, it is required to flow under its own weight. An example of each type is given below.

(a) Application to Bearing Performance

Data on bearing performance were obtained using a standardized rig test. The test bearing, a single-row cylindrical roller journal with a 4-inch bore, is mounted at the end of a horizontal shaft which in turn is mounted on two slave bearings. It is driven at 2000 r.p.m., which is slightly higher than the maximum rated speed, under a 1000-lb. radial load. No artificial heat is applied.

The bearing and end cover plate are packed with grease in accordance with the bearing manufacturer's recommendations. The bearing itself is half filled, the required quantity being 105 g. The cover plate, which is 1⅛ in. deep and 7⅝ in. in diameter, is packed with grease in the form of a half annulus with an inner diameter of 4⅞ in. to clear the nut holding the bearing, the quantity of grease being 274 g. The bearing and cover plate are mounted on the shaft vertically with the grease in the bottom half of the cover.

When the rig is started, the "clearing" stage begins. In other words, grease packed in the bearing is redistributed outside the path of the rollers. During "clearing," the bearing temperature rises to a maximum value and normally falls again when "clearing" is completed. If during the temperature rise, the yield stress of the grease in the cover falls below the critical value necessary to prevent movement, the grease will slump and be churned by the rollers. The bearing temperature may then rise to a dangerous level for a prolonged period.

The aim of this study was to correlate the churning tendency with the C.R.V. of the grease at bearing operating temperatures. Therefore, the temperature of the grease in the cover was measured continuously by a recording thermocouple, and the behaviour of the grease was observed through a hole in the top half of the cover plate. Bulk churning is seen as a continuous movement of grease past the observation hole and is unmistakable, but sometimes a discontinuous "spitting" may be confused with incipient churning and the normal "clearing" process. Therefore, the tests were always continued until churning (if it occurred) was well-developed. In some tests the "spitting" did not develop into churning, and these results are referred to as "doubtful."

Results for many greases known to have a marginal churning tendency are shown graphically in Figure 3. They include tests on various types of greases: lithium and sodium soap base greases, and non-soap greases. Each square represents a test result, its shading represents whether churning occurred, and its position on the abscissa represents the C.R.V. of the grease at the highest observed temperature. The diagram is not, in the accepted sense, a distribution plot.

Squares representing "no churning" are limited abrupt-

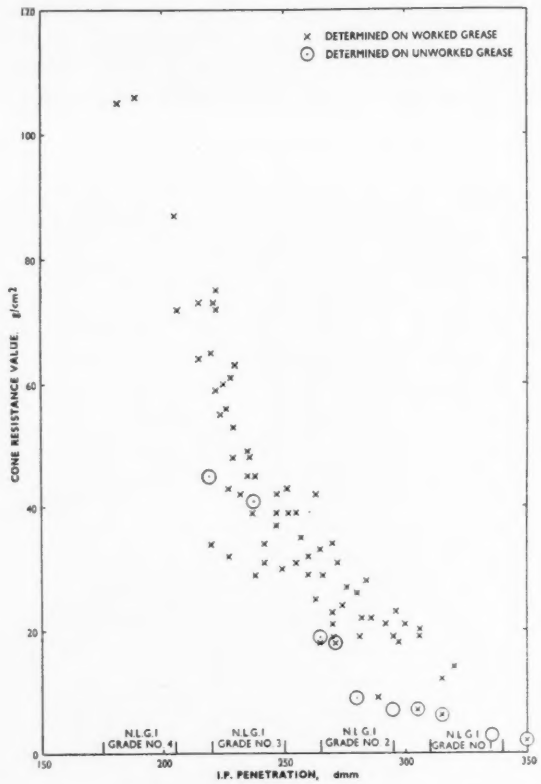

Figure 2. I. P. Penetration (Method I.P. 50) plotted against Cone Resistance Value determined at the same temperature.

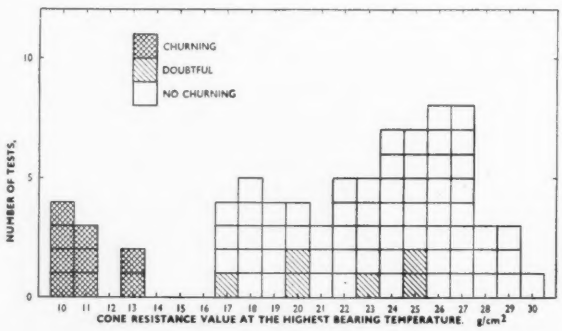
CHURNING
DOUBTFUL
NO CHURNING
NUMBER OF TESTS
0
5
10
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
CONE RESISTANCE VALUE AT THE HIGHEST BEARING TEMPERATURE, g/cm²

Figure 3. Correlation between churning tendencies and Cone Resistance Values. Each square represents a rig test result (churning, doubtful or no churning) and the C.R.V. of the same grease determined at the highest temperature observed in the bearing test of that grease.

Table I

Pumping test results for lithium, aluminum and calcium base grease 400-lb. drums

Grease	Temperature °C.	C.R.V. g./cm.² (unworked)	Yield stress τ_o lb./sq. ft.	Max. height of grease at cavitation H_c inches
A	0	45	18.0	11
A	20	41	16.4	11
B	0	19	7.6	7¼
B	20	18	7.2	5¾
C	20	42	16.8	10¼
D	0	7	2.8	5¼
D	20	6	2.4	4¾
E	20	~2	~0.8	3¼

Table II

Calculation of weight of grease remaining at cavitation 400-lb. drums

C.R.V. g./cm.²	Yield stress τ_o lb./sq. ft.	N_s	Slope angle β From Reference (8)	Weight of grease at cavitation lb. above inlet ports	Weight of grease at cavitation lb. Total W_t
0	0	—	—	0	29
5	2	10.8	9	37	66
10	4	6.5	27	55	84
15	6	5.0	67	69	114
20	8	4.3	85	85	114
30	12	3.6	90	110	139
40	16	3.2	90	134	163
50	20	3.0	90	153	182

ly with respect to C.R.V. at 17 g./cm.², which is to be expected if there is a critical yield stress, and if the test method we have chosen gives a measure of the correct yield stress. The gap between "no churning" and "churning" squares is also to be expected from the way the tests were carried out. It has already been mentioned that tests were continued to establish churning if it occurred, which means that the bearing temperature would rise well above that at which churning started and at which the critical C.R.V. was reached. Since C.R.V. usually falls with increase of temperature, the C.R.V. at the highest observed temperature will be expected to be well below the critical value.

(b) Application to Grease Dispensing

A common grease dispensing system comprises an air-driven pump immersed in the center of a drum of grease, the inlet ports to the pump being near the bottom of the drum. If grease fails to flow to the inlet under its own weight, the pump delivers air and the grease is said to "cavitate." The parameter which determines the onset of cavitation is the yield stress of the grease.

An exact analysis of the problem of slumping in a drum is difficult, if not impossible, but a similar two-dimensional problem occurs in soil mechanics as the problem of the stability of a sloping bank of soil.[8, 9] We assume the two-dimensional analysis to hold for the slumping of grease in a drum, with a suitable adjustment of constants, and also that a grease behaves as an ideal plastic-rigid material. The relationship between yield stress and C.R.V. is assumed to be the same as Equation [3].

Theory gives the critical height H_c of a stable slope to be:

$$H_c = \tau_o N_s/\rho \qquad [6]$$

where H_c is the maximum height of the grease surface at cavitation measured from the level of the inlet ports, τ_o is the yield stress, and ρ is the density of the grease. N_s is an adjustable, dimensionless parameter. Following Terzaghi,[8] if the angle of inclination (β) of the slope is greater than 60°, N_s depends only on β, and the grease slides on a circle (in the two-dimensional case) which passes through the foot of the slope, i.e. the inlet ports. If β is less than 60°, N_s depends on both β and the ratio n_D, the total depth of grease measured from the bottom of the drum to H_c measured from the inlet ports (n_D is a function of the position of the inlet). For certain values of n_D the slope fails in the above-mentioned manner; while for other values of n_D, sliding occurs on a circle tangential to the bottom of the drum.

In applying the theory, experiments were carried out on a series of lithium, aluminum, and calcium-base greases which were pumped to cavitation from 400-lb. drums. The pump inlet was 2¼-inches from the bottom, corresponding to a weight of 29 lb. of grease which could not possibly be pumped. Experimental values of H_c (given in Table I) are plotted in Figure 4 against τ_o calculated from the C.R.V. of the unworked grease determined at the slump test temperature. Values of N_s/ρ at various values of τ_o can be obtained as the slopes of the lines joining points on the curve to the origin. N_s is obtained (Table II) by assuming ρ to be 60 lb./cu. ft. In Figure 45 of his book, Terzaghi[8] gives a theoretical set of curves relating N_s to β and n_D, from which the slope angle β can be obtained for the given pump/drum combination at various values of τ_o (Table II). The grease profile at cavitation is assumed to comprise a constant slope β from the inlet ports to the radius corresponding to H_c and a horizontal surface ($\beta=0$) from this point to the wall. Thus, knowing the surface profile, the weight of grease remaining above the inlet ports at cavitation can be calculated for any value of τ_o, and the total grease hold-up (W_t) for the pump in question is obtained by adding on 29 lb. (the ideal case value of W_t).

The calculated curve is drawn in Figure 5, while the points are experimental results obtained by direct weighing. It is expected from consideration of the results of the calculations and the curves of Terzaghi that the shape of the theoretical $W_t/C.R.V.$ curve will not be sensitive to changes in the position of the pump inlet relative to the bottom of the drum. Any effect will be greatest at values of C.R.V.

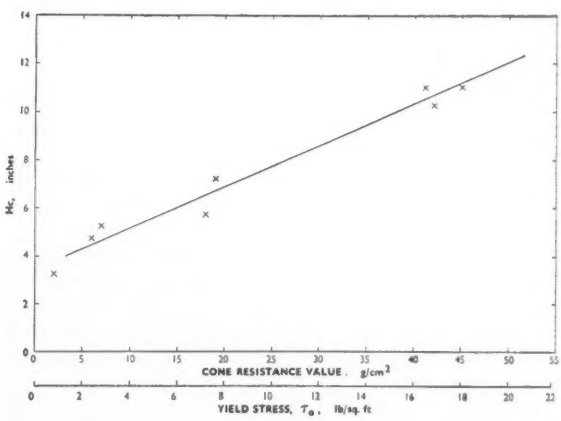

Figure 4. Grease dispensing from 400-lb. drums. Maximum height of grease above inlet ports at cavitation, Hc, plotted against Cone Resistance Value determined at the test temperature, and the yield stress (=(C.R.V.)/5·14).

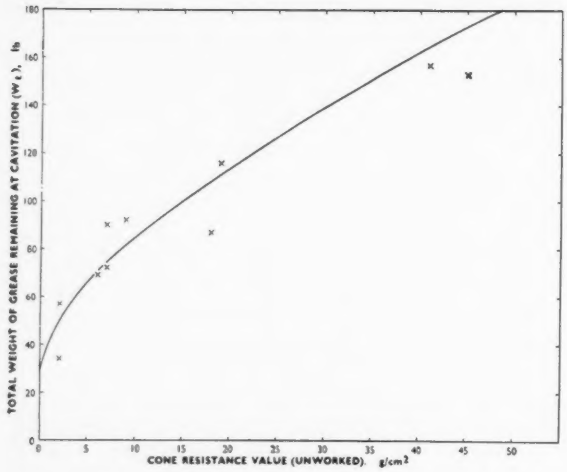

Figure 5. Grease dispensing from 400-lb. drums. Total grease remaining at cavitation, W_t, plotted against Cone Resistance Value determined at the test temperature. (Ideal case W_t = 29 lb.). The curve is the theoretical curve (see Table II) and the points are experimentally observed.

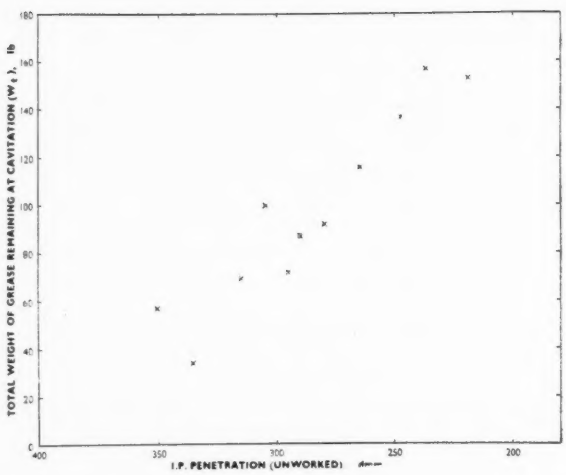

Figure 6. Grease dispensing from 400-lb drums. Total grease remaining at cavitation, W_t, plotted against I.P. Penetration determined at the test temperature.

less than 10 g./cm.^{2} Three of the experimental points on Figure 5 below 10 g./cm.^{2} were obtained with a pump, the inlet of which was much higher from the bottom than usual and left below the inlet as much as 78 lb. in a 400-lb. drum. The observed values of total grease hold-up were reduced by the amount (78-29=49 lb.) to give the values of W_t to be expected for the experimental set-up represented by Figure 5, and the agreement is good. Therefore, the curve drawn in Figure 5 is sufficiently general for practical purposes in predicting slumping in 400-lb. drums (after making due allowance for the ideal case value).

Because of the considerable vibration of the drum during pumping, which has the effect of shaking down the grease, experimental values of W_t may be less than the theoretical, especially if the grease suffers a marked decrease in C.R.V. on working.

In Figure 6, values of grease hold-up are plotted against the unworked penetration determined at the test temperature. A fairly good correlation is shown by virtue of the fact that, for the greases used in this work, the C.R.V. and the unworked penetration correlate reasonably well (see Figure 2).

CONCLUSIONS

It has been demonstrated that the yield stress of a grease, as measured by the Cone Resistance Value, is a significant factor in certain applications of grease. It is also shown that the C.R.V. should be measured at temperatures which are relevant to the particular applications in which the grease is used.

The two examples given in this paper show that an industrial grease for use in large bearings must possess a high C.R.V. at elevated operating temperatures if churning is to be avoided. On the other hand, if the same grease is to be dispensed through an automatic lubrication system, the grease must have a low C.R.V. at ambient temperatures. Obviously, a compromise must be sought, and this can be more readily achieved with greases which have a small temperature coefficient for the yield stress.

It would seem that the time has come for a critical assessment of the penetration methods for standardizing greases. It is generally agreed that these methods measure a complex property, which has no clear physical significance and, except over a very wide range of consistency, they do not correlate well with performance. The limitation on the test method to one temperature is also too restrictive. On the other hand, the Cone Resistance Value measured under closely controlled conditions as described in this paper, provides a measure of a yield stress in a quick and simple manner. The test can readily be carried out at different temperatures, and the C.R.V./temperature curves provide information which is significant with respect to the performance of greases.

The general conclusion to be drawn from the results given in this paper is that yield stress, particularly when measured as a function of temperature, is a useful property for defining the quality of a grease. More work is, however, necessary before it can be claimed that the measurement of yield stress offers any definite advantages over the measurement of the A.S.T.M./I.P. penetration value, when these are measured at the appropriate temperatures.

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★ **ASLE-ASME 4th Lubrication Conference, October 7-8-9, Toronto**

— SYMPOSIUM ON INDUSTRIAL DERMATOSES —

(Part 7 of a Series)

The Composition and Action of Protective Ointments

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EDITOR'S NOTE:

According to a recent plant survey, dermatitis in one form or another costs industry at least $100 million annually, constituting one of the major plant health hazards. Lost man-hours from dermatitis totaled 18,219 in 1955, on the basis of partial returns from fifty-nine companies able to supply information. Actually, it was revealed, 26% of employees are exposed to what the survey termed "potential skin irritants" daily. Of these, over 9 per cent incur a form of skin trouble resulting in lost manhours.

Of the 141 plants included in the survey, conducted by the American Association of Soap and Glycerine Pro-

Continued on page 359

I am not going to bore you with a pharmacological dissertation, but we have done some interesting work at the University of Michigan in regard to testing many of the so-called barrier creams or protective ointments. From the standpoint of the dermatologist, we are searching for the universal elixir, something that will absolutely repel noxious substances.

So far, we have not been able to find this elixir, but in our search we have turned up some interesting facts.

First, I will classify these protective ointments into groups. These may be broken up into four main groups.

The first one is the so-called vanishing cream type. A vanishing cream is nothing more nor less than a soapy substance which is rubbed into the skin. A very small amount is left on. The layer is infinitesimally small. It cannot protect against noxious substances; also, it is easily washed off by normal perspiration of the skin.

The second group, bland oils and fats, are best represented by lanolin or petrolatum, so-called vaseline.

The third type, neutralizers, are a little more complicated. They are expected to neutralize; for example, benzoic acid to neutralize alkaline substances; or small amounts of magnesium hydroxide to neutralize acid. Once again, visualize a tiny film 10 microns thick, with a small amount of neutralizer expected to dispel this material. It is difficult to imagine any ointment able to do this.

The fourth type, powders, are represented by the so-called calamine-lotion type and are used for repelling certain irritants of such nature as metallic dusts, particulate matter, slivers of glass, and so on.

We began our study because we were using many protective ointments in the clinic, more for the detergent type of eczema prevalent among housewives than anything else.

In 1946, certain interests came along with the silicones; the organic polydimethyl siloxanes were introduced into protective ointments because of their remarkable repellant features to water.

We began to evaluate some of the protective ointments. Our study consisted of placing on the skin a small amount of washable ink. We covered this ink with the tested ointment. We ran through some thirty ointments by washing the hands, and with the removal of the ointment we would then have the removal of the soluble ink. This did not take very long. Steady washing of ordinary briskness, the sort of thing you do in the lavatory, brought out the point that most of the protective ointments and ink were removed in thirty seconds.

We were astounded to find that some of the silicone containing protective ointments, those containing very small amounts of silicones, as well as all of the vanishing cream protective ointments, were washed off within the thirty seconds period.

The two silicone ointments which we found to be the most effective against soap and water were "Pro-Derma", which is 52.5 per cent silicone of about the viscosity of SAE 10 motor oil, in a hydrated, inert bentonite base, and "Silicote", merely 30 per cent silicone in white petrolatum.

Notice the simplicity of both of these ointments. They are extremely easy to apply, so far as worker acceptance is concerned. However, they both are greasy. They must be greasy, of course, to repel soap and water.

In another study which we did, using soluble cutting oil with one part oil to twenty parts water, we found that most of the vanishing cream types were removed in thirty seconds when the hands were washed in a tub of this emulsion. In this experiment, the best protection was afforded by the two silicone protective creams mentioned.

It was our opinion that "Pro-Derma" and "Silicote" represent the greatest advance in so-called protective ointments of recent date. They far outweighed, in protective value, all the other vanishing cream type ointments.

We tried to obtain data on protection against heavy cutting oils. We did this by putting a phenolphthalin drop on the backs of the hands, covering it with ointment, and then applying a solvent or heavy insoluble cutting oil. We found that none of these ointments, including the silicone-containing ointments, could protect against a two-minute exposure to any of the solvents for the insoluble cutting oils. So, from that standpoint, we cannot expect a great deal of protection against those substances.

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From a paper presented at the ASLE 10th Annual Meeting, Chicago, April 13, 1955

Predicting Performance of Starved Bearings

This paper outlines a procedure for determining the performance of starved bearings. In certain cases, such as wick-fed and oil-ring bearings, the rate of oil feed must be determined empirically by experiment. An extension of this procedure permits the estimation of the time of operation before failure of bearings whose oil supply has been cut off. It is known from experiment that this time may be as high as several minutes.

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NOMENCLATURE

The following nomenclature is used in this paper:

B — net width of oil film in partially filled region, in
C — diametral clearance, in.
C_p — heat capacity of oil, Btu per gal, per deg F
D — diameter of bearing, in.
G — oil quantity in bearing oil film, gal
H — horsepower loss
H_p — horsepower loss with shaft centered (Petroff)
L — axial length of bearing, in.
N — shaft speed, rpm
P — bearing load per unit projected area, psi
Q — oil flow from bearing, gpm
S — Sommerfeld number, $2.42 \times 10^{-9}\left(\frac{D}{C}\right)^2 \frac{Z_2 N}{P}$
T_1 — inlet oil temperature, deg F
T_2 — outlet oil temperature, deg F
V — film flow coefficient
W — total bearing load, lb
Z_2 — outlet oil viscosity, centipoises
e — Eccentricity, in.
g — dimensionless oil quantity in bearing
h — oil-film thickness, in.
j — power loss coefficient, H/H_p
j_1 — power loss coefficient, inactive arc
j_2 — power loss coefficient, active arc
n — Eccentricity ratio, $2e/C$
p — oil pressure, psi
p_1 — inlet-oil pressure, psi
q — oil-flow coefficient
t — time, min
θ — angle, measured in direction of rotation, from load line
Φ — attitude angle, from load line to line of centers
β — angle, $\theta - \Phi$
γ — angle
Ω — angle subtended by bearing arc

INTRODUCTION

Several types of journal bearing may operate under conditions which are properly called starved lubrication. These types include oil-ring and oil-disk bearings, wick-fed bearings, bearings with a single oil hole or oil groove at the top, and any sleeve bearing with an unduly restricted inlet orifice. In each case, starved lubrication may occur when the speeds or loads are too high.

In every bearing of finite length, oil must be supplied continuously during operation to make up for that which leaks out the ends. End leakage is caused by the load-carrying pressures generated in the oil film, and by the oil-feed pressure.

Starved lubrication occurs when the oil-feed rate to the bearing is smaller than the normal end-leakage rate. Under these conditions it is obvious that the end-leakage is reduced until it equals the rate of oil supply. The end-leakage reduction is brought about by a decrease in the angular length of the active load-carrying oil film. The balance of the clearance space will be only partially filled with oil, and will not contribute to load support.

Starved lubrication therefore results in a reduced length of load-carrying oil film. This is accompanied by smaller minimum oil-film thicknesses, higher eccentricities, higher oil-film pressures, and higher operating temperatures. Added caution is called for in designing bearings for such conditions.

DESIGN PROCEDURE

The desired solutions require a knowledge of the eccentricity n, the attitude angle Φ, the oil-flow coefficient q, and the power loss coefficient $j\Omega$, as a function of the Sommerfeld number S, the angular length of active oil

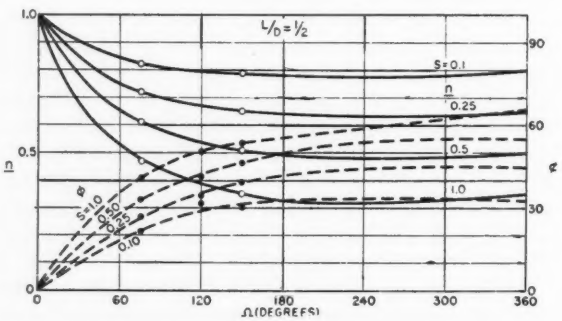

Figure 1. Eccentricity ratio n and attitude angle Φ as a function of arc length Ω, and Sommerfeld number S, for $L/D = \frac{1}{2}$.

This paper was presented at the ASLE-ASME Joint Conference on Lubrication, Indianapolis, October 10-12, 1955.

film Ω, and the L/D ratio. The solution of Reynolds' equation by an electrical analog method has been given by Needs[1] for 120-deg. centrally-loaded bearings. Cameron and Wood[2]† obtained the solution for the full 360-deg. bearing by a numerical relaxation technique. Wilcock and Rosenblatt[3] obtained solutions for bearings of 150-deg. arc using the relaxation method and a d-c network analyzer.

Recently, solutions for both 75- and 150-deg. bearings have become available using the relaxation method and an IBM card programmed calculator.[4] This range of solutions now makes it reasonable to plot the several variables as a function of angle Ω, so that interpolation for intermediate angles can be carried out.

Figures 1 to 3 show the variation of n, Φ, q and j_Ω with Ω for several values of S, at an L/D ratio of 0.5. The numerical values are given in Table I.

Figure 4 shows diagrammatically the situation in a short arc starved bearing. Except in the unusual case where $\Phi \gg \Omega/2$, the angular length of active film is $\Omega/2 + \Phi$.

Figure 3 gives the power-loss coefficient j_Ω for a centrally loaded bearing Ω-degrees long. The power loss is then expressed in terms of this coefficient and the Petroff power loss for a shaft centered full 360-deg bearing as follows:

$$H = j_\Omega H_p \qquad [1]$$

where,

$$H_p = \frac{3.79 \times 10^{-13} N^2 D^3 L Z_2}{C} \qquad [2]$$

Values of j_Ω have been computed so that they include the correction for the horizontal displacement of the shaft, according to the relation

$$j_\Omega = \frac{1}{2\pi} \int_{\pi-(\Omega/2)}^{\pi+(\Omega/2)} \frac{BC}{2Lh}\, d\theta + \frac{n \sin \Phi}{4\pi^2 S} \qquad [3]$$

The ratio B/L becomes less than 1 in the expanding region of oil film minimum approach point (see Reference 3).

In a starved bearing, it is assumed that additional power loss j_i, takes place in the incompletely filled portions of the oil film outside the arc Ω. Wilcock and Rosenblatt[3] showed that with the streamers or filmlets formed in the expanding region,[2] the power loss will be less than that for a completely filled film by the ratio B/L, where B is the net width of oil film at any angle θ. The additional power loss for partial-filled film in 360-deg. bearing is given by

$$j_i = \frac{1-n}{2\pi} \int_{\pi+(\Omega/2)-\Phi}^{\pi-(\Omega/2)-\Phi} \frac{d\beta}{(1+n\cos\beta)^2}$$

$$= \frac{1-n}{2\pi(1+n^2)^{3/2}} \left[\gamma - n \sin\gamma\right]_{\beta=\pi-\Phi+(\Omega/2)}^{\pi-\Phi-(\Omega/2)} \qquad [4]$$

where

$$\gamma = \arccos\left[\frac{n+\cos\beta}{1+n\cos\beta}\right] \qquad [5]$$

Equation (4) assumes no influence of the small amount of oil feed on the power loss. In some cases this may be large enough to be important.

Since the amount of lubricant entering must equal the amount leaving by end leakage, under steady-state conditions, the oil-film width will be increased at the oil inlet by an amount

$$\Delta B = \frac{qL}{1+n\cos\beta_0} \qquad [6]$$

where β_0 is the angular position of the oil inlet. If the oil inlet is at the top of the bearing, at $\beta_0 = 2\pi - \Phi$, the coefficient j_i becomes

$$j_i = \frac{1-n}{2\pi(1-n^2)^{3/2}} \left[\gamma - n\sin\gamma\right]_{\beta=\pi-\Phi+(\Omega/2)}^{2\pi-\Phi} + \frac{1-n+q}{2\pi(1-n^2)^{3/2}} \left[\gamma - n\sin\gamma\right]_{\beta=2\pi-\Phi}^{\pi-\Phi-(\Omega/2)} \qquad [7]$$

The total power-loss coefficient is then

$$j = j_\Omega + j_i \qquad [8]$$

The design procedure for a starved bearing can now be outlined. The "operating line method"[3] is followed to determine the operating temperature of the bearing, as shown in Figure 6. At least two points on the operating line are computed. Each point is determined by *assuming*

†A number of investigators have seen and photographed these streamers or filmlets in transparent bearings, for example, Cole and Hughes.[5]

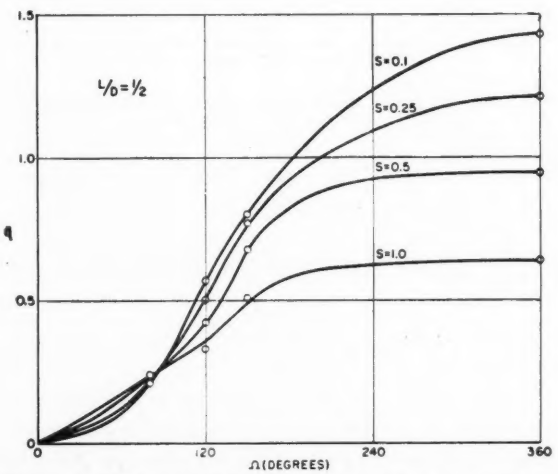

Figure 2. Oil-flow coefficient q as a function of arc length Ω, and Sommerfeld number S, for $L/D = ½$.

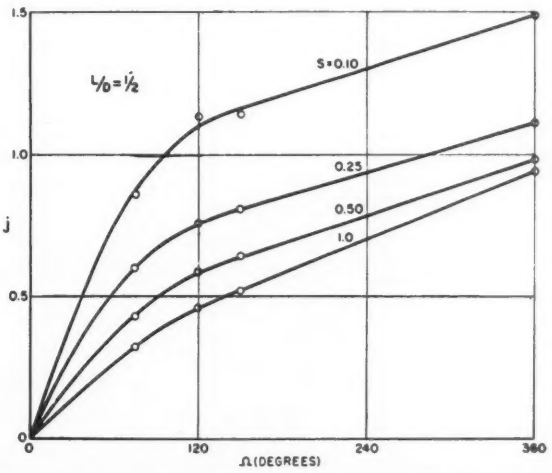

Figure 3. Power-loss coefficient j as a function of arc length Ω, and Sommerfeld number S, for $L/D = ½$.

an operating viscosity and then *computing* the bearing parameters and the operating temperatures. Plotted on viscosity versus temperature co-ordinates, these points determine the operating line for the bearing. This line represents, in viscosity-temperature co-ordinates, the performance curve for the bearing being studied. The intersection of this line with the viscosity-temperature curve representing the oil to be used, gives the operating temperature and viscosity for the bearing using this oil.

The procedure for computing a point on the operating line for a starved bearing is as follows:

(1) Determine the inlet oil flow Q, and whether it is dependent upon bearing operating variables, such as, eccentricity and attitude angle. The oil flow may be determined by conditions external to the bearing itself, for example by a valve, an orifice, a drip feeder, an oil ring, etc. Hence the flow determination cannot be generalized.

(2) Compute $q = \dfrac{294Q}{NDLC}$ (Q in gpm)

(3) Compute $S = 2.42 \times 10^{-9} \left(\dfrac{D}{C}\right)^2 \dfrac{Z_2 N}{P}$

(4) From Figure 2, determine Ω, knowing S and q.

(5) From Figure 1, determine n and Φ, knowing S and Ω.

(6) If Q is dependent upon n and Φ, repeat steps (1) to (5) until satisfactory agreement is obtained.

(7) From Figure 3, determine $j\Omega$, knowing S and Ω.

(8) Compute j_i from Equations (7) and (5).

(9) Compute power loss H from Equations (1), (2), and (8).

(10) Compute operating temperature from

$$T_2 = T_1 + \frac{42.4H}{C_p Q}$$

(11) Plot (T_2, Z_2) on viscosity — temperature chart.

(12) Repeat for other values of Z_2.

EXAMPLE — SINGLE OIL-HOLE BEARING

Assume a single oil-hole bearing, with the following values of the parameters: $D = 8$ in., $N = 3600$ rpm, $P = 150$ psi, $L = 4$ in., $P_1 = 10$ psi, $d = 0.25$ in., $C = 0.0120$ in., $T_1 = 120$ deg. F., Oil — light turbine.

In this case, the inlet oil flow is a function of eccentricity ratio and attitude angle. From the relation expressing flow between parallel plates,

$$Q = \frac{1.87 \times 10^4 p_1 V[C(1 + n \cos \Phi)]^3}{Z_2} \qquad [9]$$

where V is a film-flow coefficient equivalent to the width-to-length ratio for a rectangular slot.

It has been possible[4] to determine V mathematically for the case of a circular inlet hole centered in an infinitely long strip of parallel plates. This is a close approximation to the single oil-hole bearing, particularly, with the shaft centered. Figure 5 shows V as a function of the dimension-

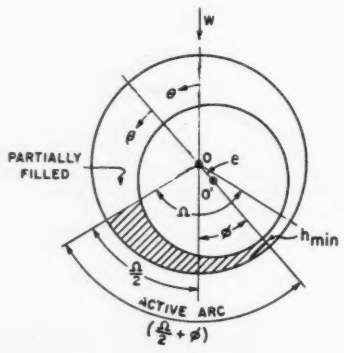

Figure 4. Diagram of bearing under starved-lubrication conditions.

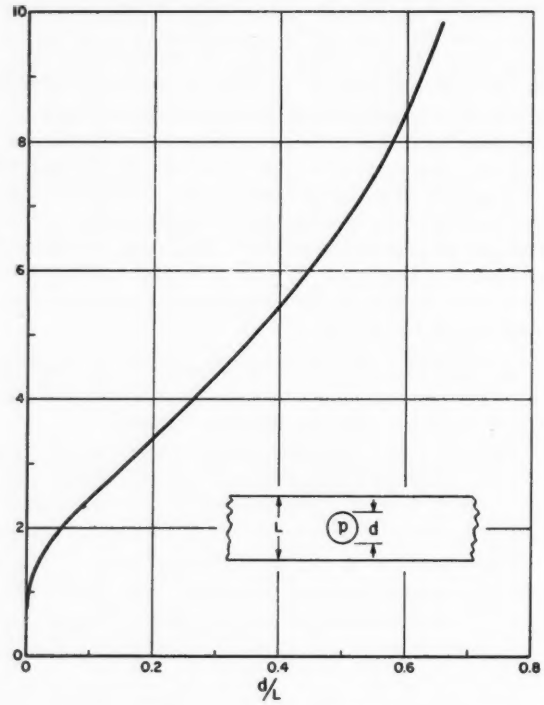

Figure 5. Flow coefficient V for film flow from a single oil-flow bearing as a function of relative hole diameter d/B.

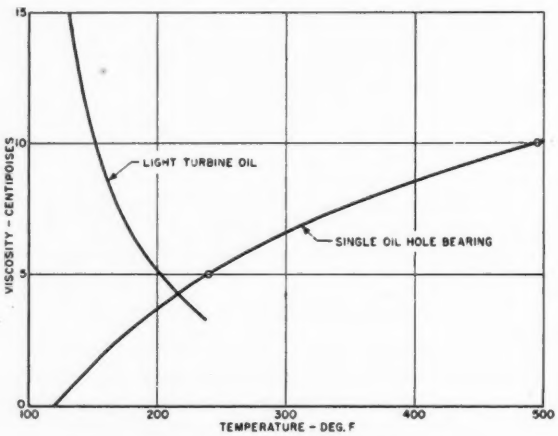

Figure 6. Operating line plot for single oil-hole bearing and light turbine oil.

less oil-hole diameter d/L, as determined from this analysis.

For this example, $V = 2.05$, and from Equation [9],

$$Q = 0.662 \frac{(1 + n \cos \Phi)^3}{Z_2} \text{ gpm} \qquad [10]$$

Assuming viscosities of 10 and 5 centipoises for Z_2, steps 1 to 6 may be summarized as follows:

Assumed					From Fig 1		
Z_2	n	Φ	q	S	Ω	n	Φ
10	0.64	45°	0.044	0.26	28°	0.85	11°
10	0.80	20°	0.076	0.26	44°	0.79	17°
10	0.79	17°	0.076	0.26	44°	0.79	17°
5	0.85	20°	0.164	0.13	70°	0.81	22°
5	0.81	22°	0.151	0.13	68°	0.81	21°

Steps 7 to 10 are then carried out as in the following summary:

Z_2	s	Ω	$j\Omega$	j_1*	j	H	T_2
10	0.26	44°	0.40	0.90	1.30	10.9	495°F
5	0.13	68°	0.76	0.88	1.64	6.9	239°F

*By Equation [4]

These points determine the bearing operating line in Figure 6. The intersection with the viscosity-temperature curve for light turbine oil indicates the operating temperature is 216° F., and the viscosity 4.3 centipoises.

The effects of the starved operation are shown by comparing these results with those for a full journal bearing of the same dimensions having two axial grooves at 90 and 270 deg. (see Reference 3). The axial groove bearing runs a great deal cooler, with higher oil flow and higher power loss.

Bearing	T_2	Z_2	Q	H	n
Single hole	216	4.3	0.8	6.3	0.81
Axial groove	152	10.1	3.6	9.3	0.65

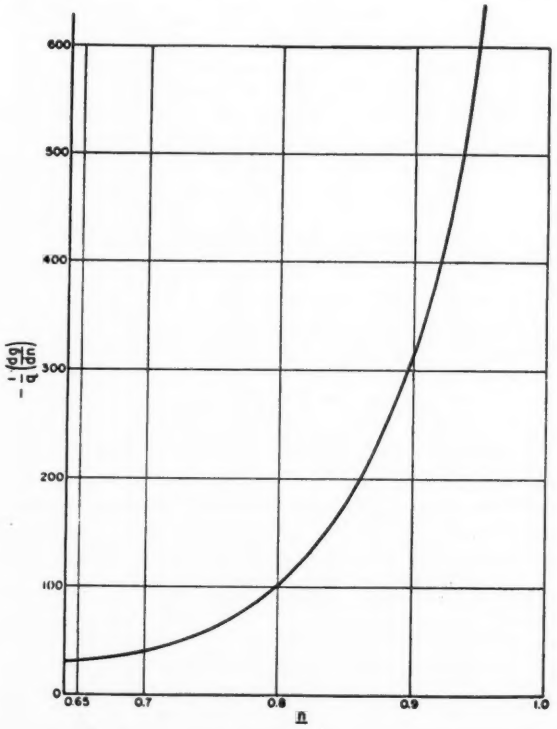

Figure 8. Function $-\frac{1}{q}\frac{dg}{dn}$ as a function of eccentricity ratio n.

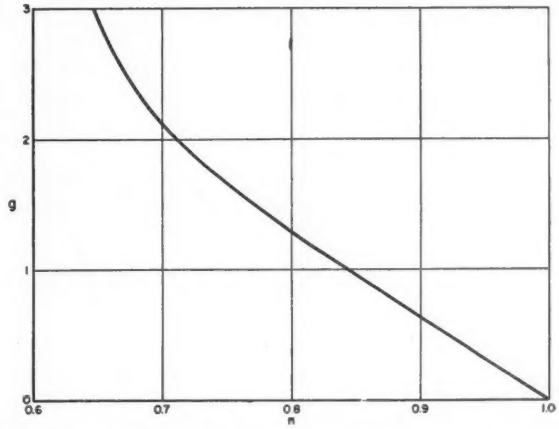

Figure 7. Dimensionless bearing oil volume g as a function of eccentricity ratio n.

A natural extension of the analysis of starved-bearing performance is the determination of the length of time a bearing will run after the oil feed is cut off completely. This is a measure of emergency safety inherent in the bearing.

While it is obviously not accurate, the complexity of the problem suggests that the lubricant viscosity be assumed to be constant after oil cut-off. This will give too long a running time, and is, therefore, an upper bound on the running time. If then the temperature rise during this time is estimated by assuming all energy loss is used in heating the oil, a second viscosity is obtained. Using this second, lower viscosity to estimate the running time will give a lower bound.

The amount of oil in the bearing at any time is

$$G = \frac{C(1-n)}{2 \times 231} L\left(2\pi - \Phi - \frac{\Omega}{2}\right)\frac{D}{2} + \frac{CDL}{4 \times 231}\int_{\beta=\pi-\Phi-(\Omega/2)}^{\pi}(1 + n\cos\beta)\,d\beta \qquad [11]$$

$$= \frac{CDL}{924} g$$

Integrating and simplifying,

$$g = 2\pi(1-n) + n\left[\Phi + \frac{\Omega}{2} - \sin\left(\Phi + \frac{\Omega}{2}\right)\right] \qquad [12]$$

Note that both Φ and Ω are functions of n, at constant S. (S is constant since Z_2 is assumed constant). Therefore, g is a function of n only. From Figure 1 and Equation [12], g can be plotted versus n.

During zero feed operation, the rate of oil loss from the bearing Q is equal to the rate of decrease of the amount of oil in the bearing:

$$-\frac{dG}{dt} = -\frac{CDL}{924}\frac{dg}{dt} = Q = \frac{NDLC}{294} q \qquad [13]$$

Simplifying

$$-\frac{1}{\pi q N}\left(\frac{dg}{dN}\right)dn = dt \qquad [14]$$

$$t = -\frac{1}{\pi N}\int_{n_0}^{n}\frac{1}{q}\left(\frac{dg}{dn}\right)dn \qquad [15]$$

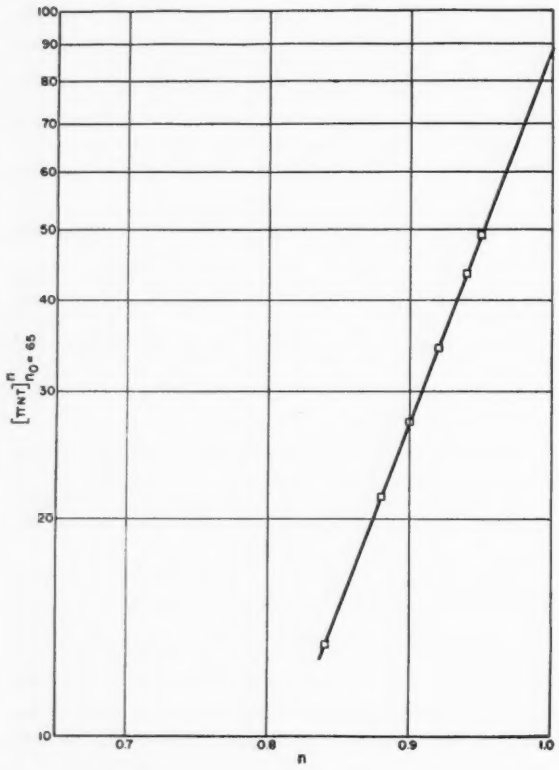

Figure 9. Area under curve of Figure 8, from $n = 0.65$ to n, as a function of eccentricity ratio n.

Equation [15] gives the time required for the eccentricity to increase from its initial value n_o, to a final value of n. The bearing will fail, or operate in the boundary lubrication region as $n \rightarrow 1$.

Note that q is also a function of n at constant S. The time integral, Equation [15], may therefore be obtained graphically by (a) plotting g versus n, (b) determining the slope, dg/dn at several values of n, (c) determining q at the same values of n, (d) plotting $-1/q\ (dg/dn)$ versus n, (e) determining the area under the curve from n_o to n, (f) dividing by πN.

Since N is in rpm, the time t will be in minutes. At constant S, the running time will be greater, the lower the speed.

Example: Assume the same bearing and conditions as in the previous example with an operating viscosity of 10 cp. Assuming an active bearing arc of $\Omega = 150$ deg., the eccentricity ratio is $n = 0.65$ and the attitude angle is $\Phi = 39$ deg. The computations required are summarized in Table II for several values of n at $S = 0.26$. Figure 7 is a plot of g versus n from which the values of dg/dn were taken graphically. Figure 8 shows $-1/q\ (dg/dn)$ as a function of n.

The estimated time to failure can now be determined by graphical integration of the area under the curve of Figure 8. The results, plotted in Figure 9, permit extrapolation beyond $n = 0.95$.

If failure is assumed to occur when the film thickness reaches a minimum of 0.0001 in. ($n = 0.983$), the time is

$$t = 73/3600\pi = 0.0064 \text{ min.} = 0.39 \text{ sec.}$$

This is the upper bound on the time since viscosity has been assumed constant at 10 centipoises. The lower bound can be computed in a similar manner by estimating the temperature rise during the starved operation period.

Note that if the speed were 1200 rpm (and the bearing load 50 psi, to keep S constant), the time of starved operation would be tripled to 1.2 sec.

Any oil remaining in feed lines or feed grooves will tend to increase the operating time. Likewise it is possible that some of the oil leaving the loaded portion of the bearing may recirculate via a meniscus at the end of the bearing and reenter the unloaded portion (see Reference 5).

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Table I

Values of S, n, q, Φ and jΩ for several values of arc length Ω and Sommerfeld number, for L/D = ½.

Ω	S	n	q	Φ	jΩ
360	0.10	0.80	1.43	33°	1.49
	.25	.65	1.21	45	1.11
	.50	.50	0.95	55	0.98
	1.0	.35	0.64	66	0.94
150	0.10	0.79	0.80	30.5	1.14
	.25	.65	.77	39.5	.81
	.50	.51	.67	46.5	.64
	1.0	.35	.51	53.5	.52
120	0.10	0.81	0.57	32	1.13
	.25	.67	.50	35	.76
	.50	.54	.42	41	.59
	1.0	.40	.33	51	.47
75	0.10	0.82	0.20	21	0.86
	.25	.72	.22	26.5	.60
	.50	.61	.235	33	.43
	1.0	.47	.235	41	.32

Table II

Effect of Oil Volume on Bearing Performance

n	Ω	Φ	g	$\frac{dg}{dn}$	q	$-\frac{1}{q}\frac{dg}{dn}$
0.65	150°	39°	2.90	−23.8	0.77	31
.70	90	30	2.12	−11.2	.29	39
.75	60	22	1.66	− 7.98	.13	61
.80	42	16	1.29	− 7.05	.07	101
.90	18	7	0.631	− 6.31	.02	315
.95	9	3.5	0.315	− 6.31	.01	631

Specific Heats of Aircraft Engine Lubricants at Low Temperatures

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The design and performance evaluation of aircraft lubricating oil systems depends on a knowledge of the thermal properties of the lubricants. There is a surprising lack of such information at low temperatures, and this is the first of a series of papers from a general research program undertaken to satisfy this need.

The present paper describes the method used to measure the specific heat of lubricating oils over the temperature range of 70°F. to −100°F., and gives related data on a typical aircraft gas turbine engine lubricant and a typical aircraft piston engine lubricant. The specific heats of the two oils ranged from 0.38 to 0.56 Btu/lb. °F. with no sharp breaks at any temperature. The piston engine oil shows an "apparent" heat of fusion totalling 4.1 Btu/lb. over a range of temperatures near its pour point. The turbine engine oil remains liquid to −100°F., but experiences a similar but smaller increase in specific heat in the vicinity of −15°F. where some clouding occurs.

INTRODUCTION

The purpose of this research program was to determine the specific heat and latent heat of fusion of typical aircraft engine lubricating oils at temperatures encountered at high altitudes and under arctic conditions. Such data were needed for analysis of lubricating oil transfer systems.[1] It was anticipated that the results would indicate whether extrapolation of higher temperature data down to —100°F. would prove suitable for most engineering calculations and which, if any, of the empirical correlations would be usable. A nonflow or batch calorimeter constructed of copper was designed for use in obtaining data in both the liquid and solid phases.

The heat capacity of liquids and solids can be determined by measuring the amount of energy required to raise the temperature of a substance by a definite amount. Heats of fusion of pure materials are determined by measuring the energy input necessary to raise the temperature of a sample from slightly below the melting point to slightly above the melting point, and correcting for sensible heat added to the solid and liquid. The apparatus generally used for such measurements is an adiabatic batch-type calorimeter.

Low-temperature calorimeters of the adiabatic type have been constructed, and their operation and performance discussed by several investigators.[2−9] They have been used in measurements of specific heat, heats of vaporization, fusion, and transition of liquids, solids, and condensable gases.

To approximate adiabatic conditions, the calorimeter is maintained in a high-vacuum vessel, thereby making the heat losses by convection through the gas space between the calorimeter and the outer jacket negligible. Heat losses

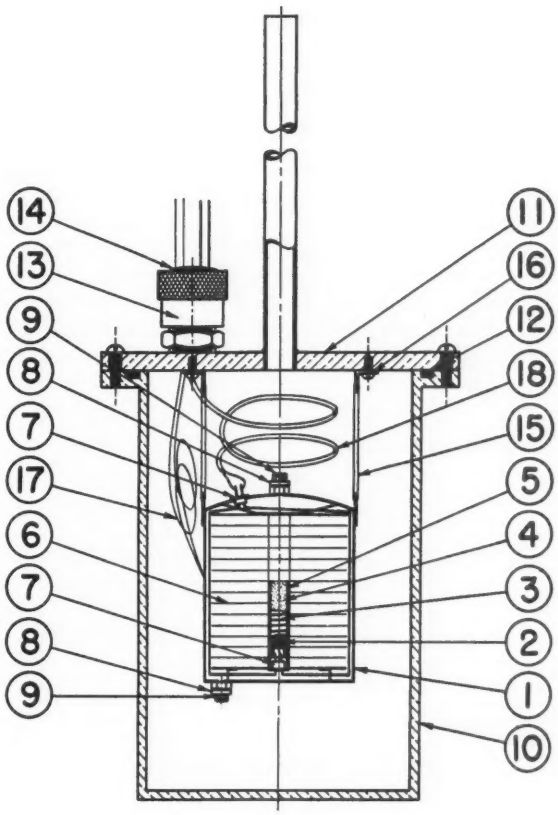

Figure 1. Calorimeter assembly. Key: (1) calorimeter, (2) Bakelite heater core, (3) 30-gauge nichrome wire, (4) cold solder, (5) copper cylinder, (6) copper fin, (7) Stupakoff Kovar seal, (8) plastic gasket, (9) drain and filling plugs, (10) calorimeter jacket, (11) calorimeter jacket cover, (12) silicone O-ring, (13) ⅜″ sealastic fitting, (14) neoprene rubber, (15) nylon thread, (16) hangers for calorimeters, (17) B & S 40-gauge Teflon-covered copper-constantan thermocouple wire, (18) heater leads.

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due to radiation are small because surfaces are gold-plated and polished, temperature differences are small, and the absolute temperatures are low. Consequently, it would appear that the most significant heat exchange between the calorimeter vessel and the surroundings is that of thermal conduction along the electrical leads to the heater, and the thermocouple leads incorporated in the calorimeter vessel. This was corroborated for the present apparatus by calculations which indicated the radiation at room temperature accounted for approximately 15% of the heat losses; the remainder, resulting from the conduction along the heater and thermocouple leads.

Extensive measurements of specific heats and latent heats of organic compounds have been made by Parks[9] in a calorimeter in which the material was placed in a sealed copper can containing an electrical heater with vanes to aid in the distribution of heat within the sample. The remaining space in the calorimeter was then evacuated, and the temperature after heating for short periods of time was measured with a calibrated copper-constantan thermocouple. Aston[4] and Giauque[8] have made excellent measurements of both specific heats and heats of fusion of several compounds to temperatures as low as 14°K. The apparatus used by each investigator was similar to the calorimeter used by Parks.

Other methods have been employed for the determination of specific heats. The "twin calorimeter" invented by Joule and improved by Richards and Gucker[10, 11] utilizes two resistance heaters in series, one immersed in the test fluid and the other in water. Since the current is the same in the two heaters and the heat lost to the surroundings is comparable, the specific heat of the test fluid is related to that of water in terms of the temperature rise of each and the resistance of the two heaters. Burlew[12] has developed what he calls the piezo-thermometric method which is capable of measuring the specific heat of liquids using a very small sample, about 5 cc. The extensive use of the batch-type adiabatic calorimeter by other investigators, and its suitability for determination of heat of fusion and specific heats of solids, lead to its selection for the present investigation.

Table I

Physical Properties of Oils Tested

	Turbine Lube MIL-O-6081A, Amend. 1 Grade 1010	Piston Engine Lube MIL-0-6082 Grade 1080*
Color	1 —	——
Appearance	Clear, Transparent	——
Neutralization No.	0.01	——
Precipitation	0	——
Copper Corrosion (3 hr. at 212°F.)	Pass	——
Viscosity:		
CS. at 100°F.	10.316	——
at −40°F.	2810	——
SSU at 100°F.	——	756
at 130°F.	——	329
at 210°F.	——	78.3
Viscosity Index	104	101
Flash, COC, °F.	295	460
Fire, °F.	——	530
Pour Point, °F.	Below −80	5
Gravity, API	29.9	28.5

*AeroShell 80, Shell Oil Co.

APPARATUS & PROCEDURE

The experimental equipment consisted of the calorimeter, electrical heater power source and measuring equipment, a timing circuit, and a constant-temperature bath. The calorimeter (see Figure 1) was a cylindrical copper container 2.25 inches tall, 2.15 inches in diameter, and having a volume of approximately 135 cubic centimeters. A finned heating element was mounted axially. In the design of the finned heating element, consideration was given the need for minimizing the mass of the calorimeter as compared to the contained volume. At the same time, it was necessary to provide adequate distribution of the heat to avoid serious departure from thermal equilibrium during the heating period. The complete calorimeter weighed 102 grams, resulting in a favorable ratio between the heat capacity of test sample and heat capacity of the apparatus.

After being filled with the test sample, the calorimeter was suspended by nylon thread from the cover of the vacuum vessel. To achieve a close approach to thermal isolation of the calorimeter, the lead wires were made small with some excess length to minimize conduction, and all surfaces were gold-plated and polished to minimize radiation.

Calorimeter and bath temperatures were measured using copper-constantan thermocouples made from select wire (40 gage). The thermocouples were calibrated using the nitrogen boiling point, the mercury freezing point, and the toluene freezing point as standards. Calibration data were used to obtain constants for the empirical equation

$$e = at + bt^2 + ct^3 \qquad [1]$$

where e is the thermocouple emf referred to 0°C., and t is the temperature in °C. Calculation of the temperature rise was made from the slope of the calibration curve (obtained by differentiation) with an average precision of ±0.003°C.

Thermocouple emf was measured with a Leeds and Northrup White Double-Bridge Potentiometer and a high-sensitivity galvanometer, L and N model 2284 (Figure 2).

Heater power supply was provided by 6-volt storage batteries and measured by calibrated deflection instruments. To avoid transient effects when heating the calorimeter, a dummy heater having the same resistance as the one in the calorimeter was used to stabilize the current before a test was begun.

The timing circuit consisted of a pneumatic time-delay relay and two electric clocks which could be read to ±0.02 seconds. The time-delay relay not only served as a means of setting the duration of the heating period, but also served as a double-pole double-throw switch between the dummy heater and the calorimeter heater.

Methanol in a large dewar with a capacity of 12 gallons provided a constant temperature bath for the calorimeter. Solid carbon dioxide was used to cool the system to the desired temperature level; two calrod heaters were used to warm the bath to a new temperature level after each specific heat determination. Control of the bath temperature was accomplished manually by periodically dropping in a pellet of dry ice about the size of a pea. This procedure resulted in a bath temperature constant within ±0.025°C.

In preparation for testing, the calorimeter was thoroughly washed with carbon tetrachloride, dried, and weighed. It was then carefully filled, the exterior wiped free of any sample material spilled, and then weighed again.

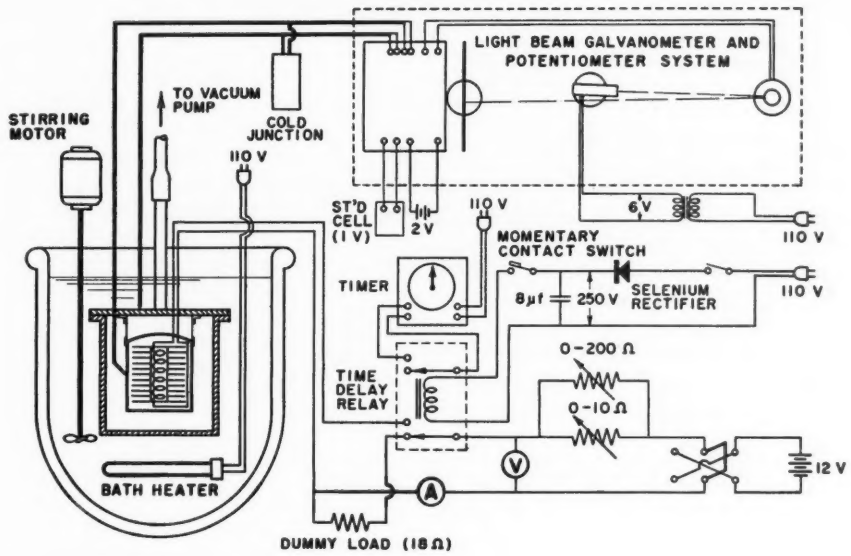

Figure 2. Calorimeter system.

During a test, the calorimeter temperature was adjusted to the desired level and the bath adjusted to a temperature approximately midway between the initial and final temperatures of the calorimeter. This procedure resulted in reversal of the heat exchange between the calorimeter and its jacket, thus minimizing the error due to heat exchange.

When the desired initial conditions were established, the run was started by pressing a momentary contact switch in the timing circuit. This changed the load from the dummy heater to the calorimeter heater. Duration of the heating period was obtained automatically, and the operators recorded power input, bath temperature, and calorimeter temperature at frequent intervals for a period of time ranging from 15 to 20 minutes. A typical time-temperature history (actually emf v.s. time was used for convenience) is shown in Figure 3. The temperature rise was obtained by extrapolating the linear portion of the curve after the heating period back to the end of the heating period, subtracting the emf at the beginning, and converting emf to temperature.

Empirical Equations

Several empirical equations have been developed from data for petroleum in the temperature range 0 to 1000°F.[13-18] Gaucher[15] presents an equation for petroleum fractions which requires specific gravity and boiling point data. His equation correlated most available data at the time (1935) for pure hydrocarbons and petroleum fractions with an average deviation of 1.3% and a maximum of 6%.

Fortsch and Whitman[13] presented the following equation based on their experimental data for fifteen petroleum oils:

$$c = \frac{(t' + 670)\ (2.10 - Sp.\ Gr.)}{2030}, \text{Btu/lb.°F.} \quad [2]$$

where t' = temp., °F.; and $Sp.\ Gr.$ = specific gravity, 60°F./60°F. These data were later presented in the form of a nomograph by Wilson.[14]

Eckart[16] presents an equation in terms of specific gravity alone:

$$c = 0.3105\ (2.295 - Sp.\ Gr.), \text{Btu/lb. °F.} \quad [3]$$

In this equation the dependence upon temperature is presumed just as the temperature affects the density.

Karawajeff[17] presents an equation for oils which involves the temperature only.

$$c = 0.000428\ (t' + 1006), \text{Btu/lb. °F.} \quad [4]$$

Bailey and Edwards[18] offer a similar equation with slightly different constants.

$$c = 0.000470\ (t' + 892), \text{Btu/lb. °F.} \quad [5]$$

These equations are apparently suitable for the temperature range for which each was evaluated. Extrapolation, particularly to lower temperatures where phase change will occur, would not be advisable. The experimental results of the present investigation will be compared with these equations.

Discussion of Results

The specific heat data presented herein are mean values for a temperature range of 2.2 to 2.8°F., and are reported at the mean temperature. The values were computed from

$$\bar{c} = \frac{q_{net}}{m\,t'} \quad [6]$$

where: $\bar{c}$ is the mean specific heat, Btu/lb.°F.; q_{net} = net heat supplied, Btu; m = mass of sample, lb.; and t' = temperature rise, °F.

The net heat added was computed from the electrical energy supplied, and account was taken of the dissipation

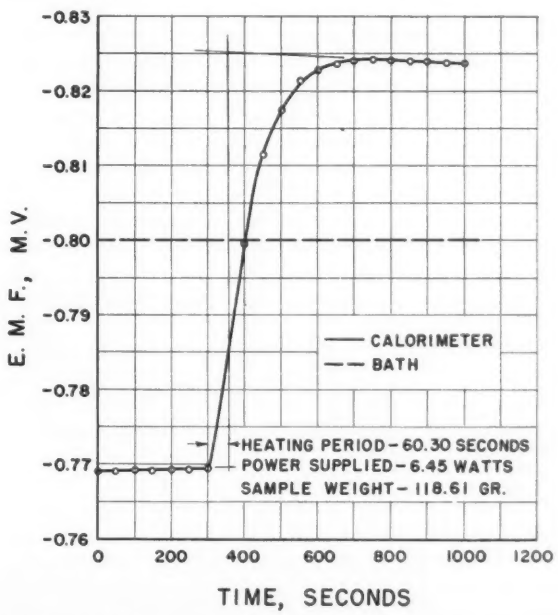

Figure 3. Typical time-temperature history.

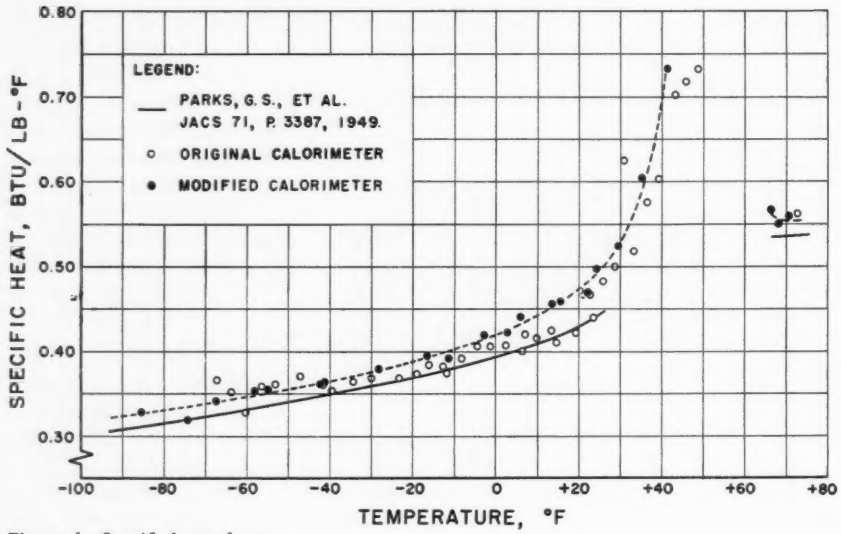

Figure 4. Specific heat of cetane.

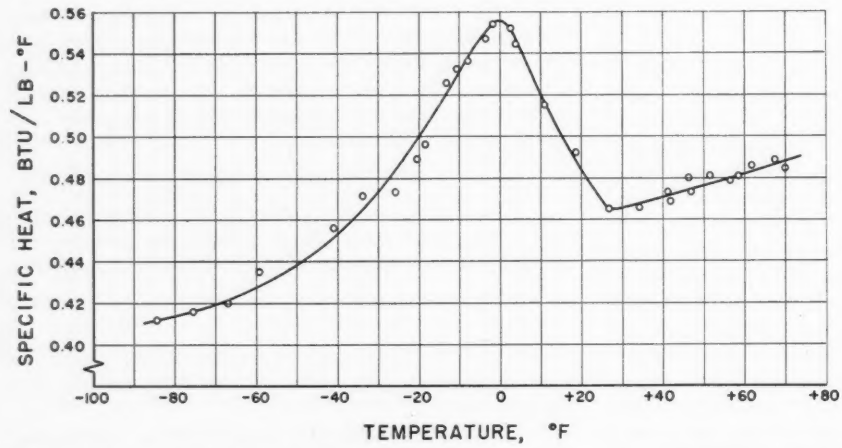

Figure 5. Specific heat of piston engine lubricant.

in lead wires and the heat capacity of the calorimeter. Heat capacity of the calorimeter was measured when empty, following the same procedure employed during the usual tests. This was necessary because part of the apparatus was fabricated of material of unknown heat capacity. To check the result of this preliminary test, the slope of the curve was compared with that for copper given by Perry.[19] It was also found that this procedure was preferable to computing the capacity from known specific heats, since the same interpretation was then placed on time vs. temperature history in obtaining the calorimeter temperature rise.

An analysis of the errors indicates a probable error of 1.29% which appears reasonable compared with the deviation of points from the mean curves. The final results are considered to be within 2% of the absolute values.

In order to establish the accuracy of the calorimetric system, data were obtained for water, cetane, and toluene. Water data and some cetane data were obtained in an earlier calorimeter, but successive freezing and thawing of the cetane caused leakage of such an extent that the apparatus was abandoned. In the redesign of the apparatus to overcome the leakage problem, other changes were made which improved the accuracy. Additional data for cetane and data for toluene were obtained in the new apparatus.

The cetane data, Figure 4, are compared with those of Parks.[9] It is seen that the results obtained in this investigation are about 5% higher than those of Parks, but it is believed that this was caused by lack of purity of the sample tested. Cetane (normal hexadecane) is difficult to store without decomposition.

The toluene data show excellent agreement with those of Burlew[11] who reports excellent agreement with the average of seven observers' results and claims a precision of 0.25% for his own. The present data are 3 to 4% higher than reported by Kelly.[20]

Water data collected in the first calorimeter scattered rather badly (±2%), although the mean compared very well with the data of Osborne, Stimson, and Ginnings.[21] Leakage was probably responsible for the scatter of the data.

The heat of fusion of cetane was also measured to establish the validity of the procedure, and the value obtained (91.2 Btu/lb.) was about 7% lower than the value obtained by Parks. Since the accuracy of fusion heat measurements was considerably less than specific heat measurements, the agreement with Park's data is considered satisfactory. Also the value seems to be consistent with the specific heat data, i.e., presuming Park's data to be the absolute values for the pure material, impurities would tend to increase the specific heat and decrease the heat of fusion as a result of the phase change occurring over a range of temperatures.

The two oils selected for these tests were a piston engine lubricant of military specification MIL-0-6082, grade 1080,[22] and a gas turbine engine lubricant of military specification MIL-0-6081 A, grade 1010.[23] Physical properties are presented in Table I to the extent that they are available. Both military specifications have been superseded since the samples were obtained. The properties given in Table I should be useful in determining the applicability of the present data for computations on oils of similar characteristics. The first oil contains no additives, while the second contains minor amounts only.

Figure 5 shows the data for MIL-0-6082, grade 1080 piston engine oil. This oil has a pour point at about 5°F., and becomes solid at about —10°F. As the phase change occurs, the oil appears to have a continuous specific heat, contrasted to the infinite value of the property for pure substances. To define the apparent heat of fusion, the

sensible heat was considered to be that obtained by extrapolating together the liquid and solid data. All requirements in excess of that amount are then considered latent heat of fusion. Graphical integration of Figure 5 then gave an apparent heat of fusion of 4.1 Btu/lb.

In order to establish that no infinities existed in the unexplored gaps between test points, a run was made covering a large range of temperature, and the apparent heat of fusion obtained by subtracting the sensible heat. The same result obtained, indicating that no infinities exist in that temperature range.

The heat of fusion found for the piston engine oil was remarkably low compared to that for a typical pure hydrocarbon as, for example, cetane. These results clearly indicate that it would be incorrect to assume the heat of fusion of a lubricating oil to be the same as that of a representative pure hydrocarbon. Hydrocarbon oils may solidify to a glassy state, to a crystalline state, or a combination of the two. The low fusion heat measured indicates a small amount of crystallization in this oil. Bondi[24] discusses the effect of partial crystallization on the viscosity of oils. It is noted that such oils may require several days to achieve an equilibrium state at a particular temperature. The present data were obtained by cooling the sample to a low temperature overnight, and then making a series of runs the following day at progressively higher temperatures. Since subcooling hastens crystallization which would occur at higher temperatures, it is likely that crystallization was relatively complete for all but the lowest temperature runs. Also inspection of Figure 5 indicates that the waxes separate in the temperature range from —50°F. to +25°F.

The data for MIL-0-6081A, grade 1010 turbine engine oil are shown in Figure 6. These results display a general decrease of specific heat with decreasing temperature, except that a departure from the trend occurs in the vicinity of the cloud point. In this region, the specific heat is as much as 7% higher than the trend of the data above and below. Evidently some crystallization occurs, although the oil will pour below —70°F. The 1010 oil does not become solid and has no heat of fusion other than the effect mentioned above down to a temperature of —100°F.

The empirical equations given earlier in the paper were tested for their applicability in the low-temperature range. At 60°F., all of these equations predict values within 2% of the 1010 data which is 8% lower than the 1080-grade oil at that temperature. At a temperature of —90°F., the Fortsch equation predicts values very much lower than those found in this investigation. The others are somewhat better, with the Karawajeff being the best compromise for the two oils tested. None of these equations will predict the fusion heat and, since the temperature range in which fusion occurs is quite large, they would not be suitable for predicting heat capacity in the low-temperature range.

CONCLUSIONS

(1) Specific heat data obtained in this investigation are considered to be within 2% of the absolute values for the materials tested. Substantial agreement was found between the experimental data for water, cetane, and toluene and the established values for these materials. The experimental heat of fusion data are less accurate than the specific heat data, but reasonable agreement exits with the published value for cetane.

(2) Both oils tested display continuous finite specific heats over the range of temperatures investigated. There is no sharply defined latent heat of fusion as for pure materials, but an apparent heat of fusion may be determined to demonstrate that this property of a petroleum lubricant is definitely not predictable from data for representative pure hydrocarbons. An apparent heat of fusion is, however, probably not of value in calculations because the influence of phase change covers such a wide temperature range.

(3) Existing empirical relations for the prediction of specific heats of petroleum oils are inadequate for accurate calculations in the low-temperature range. New correlations were not obtainable from the limited data obtained in this investigation.

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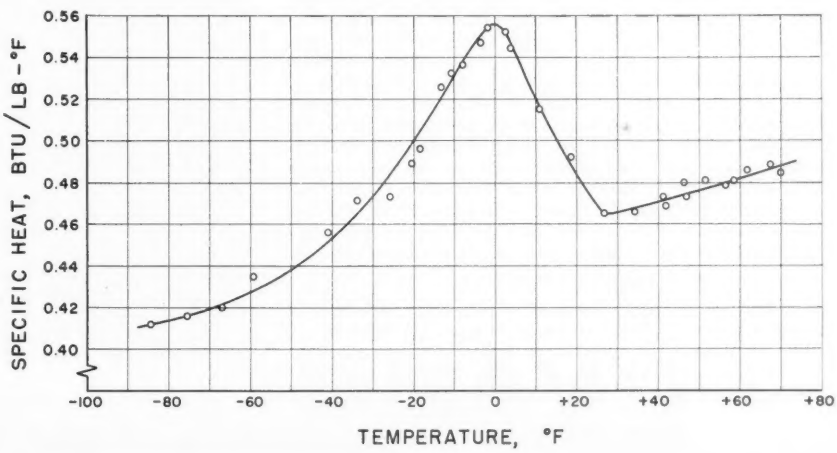

Figure 6. Specific heat of turbine engine lubricant.

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COMMENTARY

H. A. HARTUNG, THE ATLANTIC REFINING CO.

This paper presents the results of careful study of a difficult problem. The authors must be commended for the scientific way in which they have attacked this problem, and for the precise methods and equipment they have used.

It is unfortunate from a scientific viewpoint that they have selected proprietary compounds to study. The problem they were called upon to solve undoubtedly involved lubricants of these types, but it should be pointed out that there may be no such thing as "typical" products here in the sense the authors use the word. For instance, the MIL-0-6081A specification permitted the use of pour depressants and oxidation inhibitors. There are many of these additives, and it is possible that the differences among the thermal properties of various formulations could be very large. This is especially true where phase changes are involved. Where such exact work is being done on a product, it would seem preferable to use precisely specified materials.

On one other point, constructive comment may be pertinent. This is the assumption by the authors that crystallization was relatively complete when samples were cooled to a low temperature overnight and tested the following day. In hydrocarbon systems, crystallization and other phenomena depending on diffusion can show some unusual effects. For instance, precipitation of a solute from oil solution sometimes occurs faster with moderate than with more severe subcooling. One explanation for this is illustrated in Figure I. Here it is assumed that the degree of subcooling is the driving force for the diffusional change, while the viscosity of the oil is the resistance; the rate, then, is proportional to the quotient of these two (ordinate). The data shown are for the authors' turbine engine lubricant. For this purpose, subcooling below the pour point is considered the driving force; in other cases, different base temperatures may apply. Note that the rate shows a pronounced maximum at moderate subcooling. This effect has been found in a number of studies involving stability of hydrocarbon solutions. It is usually necessary to compare results obtained with different times of exposure to the selected low-temperature condition to be certain that equilibrium has been reached.

It is hoped that more effort will be directed toward the study of thermal properties of lubricants, both at very low and very high temperatures. The project described in this paper sets a standard for workmanship which may well be emulated.

AUTHOR'S CLOSURE

The authors would like to thank Mr. Hartung for his very constructive comments. The first was with regard to the materials selected for study. The research was sponsored by the U. S. Air Force, and the materials were chosen as being fairly representative of the lubricants in use by the Air Force at the time the work was initiated. It is certain, however, that the data will not apply in general, within the precision of the measurements, to other lubricants. The turbine lubricant did contain additives, while the piston engine lubricant did not. As Mr. Hartung points out, the influence of additives of various amounts and kinds may be considerable. It is also quite possible that materials not containing additives may have closely the same mechanical properties, but somewhat different thermal properties, depending upon the formulation. These facts point up the need for more extensive research in this area using a range of carefully selected and well defined products. It is the authors' hope that until such additional data are forthcoming, the present data will serve the need for closely-similar materials and as a guide in extrapolating data for other materials.

Mr. Hartung's second point was with regard to the rate of crystallization. His illustration of the rate of crystallization is very interesting indeed, although the relative rate appears reasonable over a considerable range of subcooling. The time and degree of subcooling was not the same for all measurements and, as a result, the reproducibility was not as good in the region where phase change was evident. This past history effect was noted, but the amount of scatter in the data was still not excessive; this fact led to the conclusion that the crystallization was relatively complete. As a result, the time and degree of subcooling was not recorded, and more positive proof of the authors' supposition cannot be offered.

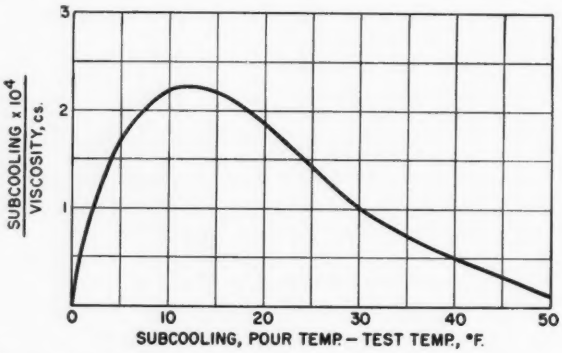

Figure I. Rate of attainment of equilibrium vs. degree of subcooling for MIL-O-6082 piston engine oil.

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Continued from page 327

application are used annually in production as well as quality control on billions of dollars worth of manufactured products.

A list of exhibitors included Acheson Colloids; Alemite Division, Stewart Warner Corp.; Alpha Molykote Corp.; Bal Crank Co.; Carbide and Carbon Chemical Co.; City Service Petroleum Co.; Commercial Filters Corp.; Dearborn Chemical Co.; Dravo Corp.; Farval Corp., Cleveland Worm and Gear; Hanafin Corp.; Fiske Bros. Refining Corp.; Hilliard Corp.; Hohman Plating and Mfg. Co.; E. F. Houghton and Co.; Jes Co. Lubricants Co.; Lincoln Engineering Division, MacNeil Machine and Engineering Co.; McCord Corp.; Houdaille Industries; Monsanto Chemical Co.; National Refining Co.; C. A. Norgren Co.; Penn Petroleum Corp.; Pure Oil Co.; Pyles Industries, Inc.; Shell Oil Co.; Sinclair Refining Co.; Socony Mobil Oil Co.; Standard Oil Co. (Indiana); Texas Co.; Trabon Engineering Co.

SPECIAL EVENTS

The distaff side, well represented at the meeting, participated in a somewhat strenuous program arranged by Hostess Isabelle Brady. On Monday, April 15—Noonday Luncheon at the Veterans Memorial Building and a tour of Detroit's new Civic Center. Tuesday—a drive through Fairlane, the late Henry Ford's estate, followed by lunch at the Dearborn Inn. This was followed by a tour of the Ford Rotunda and a trip through the Greenfield Museum. This returned the ladies to their hotel where they participated in a cocktail party preceding the Annual Awards Dinner. On the concluding convention day, April 17, the program was rounded out by luncheon and a tour of the Northland Shopping Center.

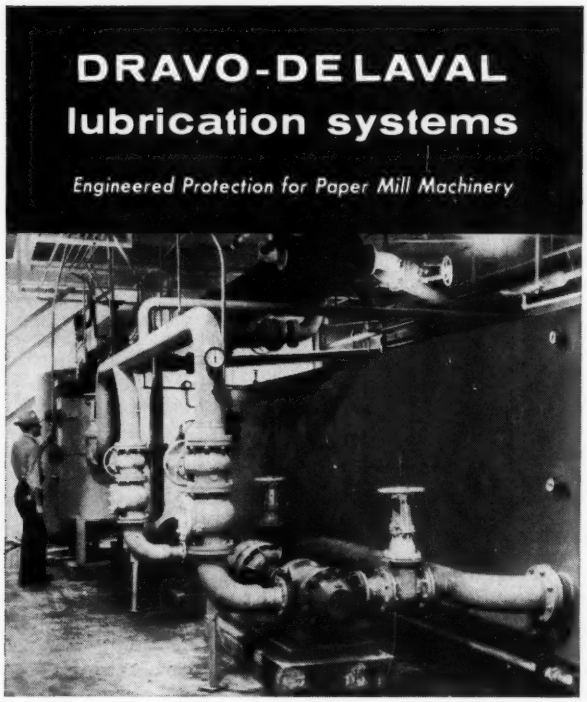
All members were welcomed by Detroit ASLE Chairman James A. Brady, who assigned every Detroit member to the "Greeting Committee". They wore green and white tabs for easy spotting by the visiting delegates, and offered invaluable assistance in threading a path through the numerous exhibits and sessions.

At the Annual Meeting Banquet on April 16, members and guests were entertained by the dance music of Warney Ruhl and his orchestra, with the charming vocalist Patti Brown. Jack Hubert proved a thoroughly enjoyable comic, and kept the evening effective in the lighter vein.

Industrial Dermatoses

Continued from page 347

ducers, it was indicated that many were not aware of the extent of the problem posed by dermatitis, nor the amount of lost time it incurred. This would make the actual figure of time and dollar loss resulting from dermatitis much higher than that actually registered. In a report by Dr. Louis Schwartz, former director of the U.S. Public Health Service, it was pointed out that over one per cent of industrial workers at any given time are affected with industrial skin diseases of varying severity.



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Lubrication Abstracts

(Compiled by the ASLE Abstracts Sub-Committees.)

BEARINGS
Lubrication

BARWELL, F. T., HUGHES, M. J., "Some Further Tests on High-speed Ball-bearings," *Proceedings of Inst. of Mech. Engrs.*, n. 36, *Vol. 169*, 1955.

Friction torque and natural running temperature of 'light' type and 'extra light' type bearings of bore 5 inches are measured at speeds ranging from 5,000 to 11,000 r.p.m. Loads up to 2,400 lb. are applied at varying incidence of radial to thrust load. Lubrication is by liquid jet at the rate of 6 pints per min. It is concluded that a large proportion of the friction measured under the conditions of lubricant supply adopted in the experiments is attributable to viscous friction in the lubricant. An analysis of the friction torque based on the work of Poritsky, Hewlett, and Coleman (1947) for varying angles of application of load shows no correlation with the experimental results obtained. Estimates of hysteresis loss based on the work of Tabor (1952, 1954) indicate that this factor represents a compaartively small proportion of the total frictional loss of bearings of this type. (Author's Abstract)

"Design of Cam Followers," by M. Kloomok and R. V. Muffley, *Product Engineering, Vol. 27*, No. 9, Sept., 1956, pp. 197-201.

Design methods for using rolling contact bearing mounted roller cam-followers are outlined and illustrated by a sample problem. Advantages claimed over plain-bearing-supported rollers are (1) reduction in cam-roller friction, (2) reduced wear, (3) better dimensional control. Bearing manufacturers' catalogue data for cam-follower antifriction bearings are reproduced. A Nomograph for computing allowable normal loads (for steel-steel) is presented. Some commonsense design hints are included. (C. M. Allen).

"A Look at Some (Aviation Gas) Turbine (Ball) Bearing Problems," G. C. Barnes and E. A. Ryder, Society of Automotive Engineers, Paper No. 693, presented January, 1956, Detroit. 8 pages, 6 illustrations.

Two generalized important problems in turbine ball bearings are pointed out: (1) increase in minimum life or elimination of premature failures (2) production of reliable bearings for use at higher temperatures. Turbine bearings should be of the highest possible precision, as the greatest possibility for increasing life and reliability lies in metallurgical advances in vacuum melting, heat-treatment, and material composition. Graphical data suggest the existence of a fatigue limit for ball bearings. A curve of fatigue life versus lubricant viscosity indicates that life is significantly increased for the higher viscosity lubricants. Rotating beam fatigue tests on SAE 52100 steel indicate that the optimum hardness of the steel is about Rock. C 58. This appears to be within the hardness range of the maximum microelastic limit. Of the high-speed tool-steel materials, MV-1 appears to offer the most immediate promise for high-temperature ball bearing use. Metallurgical control and many experiments at high temperature, high load, and high speed are still required. (C. M. Allen).

"New Oil-Less Bearing Material," J. D. Shaw and W. V. Knopp, *Product Engineering, Vol. 28*, No. 1, January, 1957, pp. 203-205.

A new bearing material, made by hot pressing metal-graphite powders, is described as having good friction and wear characteristics over a wide temperature range. A wide variety of metals is used with graphite. Temperature ranges for various metal-graphite materials are: bronze —300 to 750 F; iron, —300 to 1250 F; nickel, —300 to 750 F. No friction or wear data are presented for the above temperatures. Data on the effect of graphite content with bronze show that the strength decreases with increasing graphite content while friction and wear are reduced. Friction and wear data for temperatures of 125 to 232° F are presented for a material of German origin and known as Deva-metal.

COLE, J. A., HUGHES, C. J., "Oil Flow and Film Extent in Complete Journal Bearings," *Engineer, v. 201*, n. 5225, 1956, p. 255-8, n. 5226, p. 263-5; see also *Chartered Mech. Engr., v. 3*, n. 2, p. 75-6.

In 360-deg. journal-bearing theory, the load-carrying film is assumed to be partial as a result of cavitation in the diverging outlet film, but the friction-producing film is taken as complete. The effect of oil inlet conditions on film extent and the state of affairs prevailing in the cavitated film have been matters for speculation. A method is developed for photographing the oil film in glass bearings of standard clearance ratio (0.001 and 0.002) and the results of a qualitative and quantitative examination of film extent are described. The measured oil outflow rates are analysed by separation into the hydrodynamic and supply-pressure-induced components, and explanations for an apparent deficit in the former are discussed. (Authors' abstract)

GIARRAPUTO, L. F., "Stainless-Steel Bearings for Film-Processing Machines," *Soc. Motion Picture and Television Engrs. Jnl. v. 65*, n. 6, 1956, p. 328-9.

An overall investigation of bearings for operation in corrosive solutions is described. Some designs of sleeve and antifriction bearings using synthetic plastics and variations of conventional designs which proved unsatisfactory are reviewed. A two-piece, deep groove ball bearing made entirely of No. 316 (18-8) stainless steel is the final development. Large balls are used to keep starting torque low, while a special open pocket design makes the ball pockets self-flushing. If allowance is made for the lower load and shock capacity of the material, excellent bearing life can be expected. (Abstracted by F. J. Kolano)

RYDER, E. A., BARNES, G. C., "A Rapid Fatigue Test for Rolling Contact Materials," *Am. Soc. Testing Matls., Bul. n. 217*, October 1956, p. 63-4.

It is suggested that fatigue evaluation of ball bearing materials for high-load, high-temperature, high-speed, jet-engine applications will best be carried out by bench type testing rather then by actual engine testing. A simple fatigue test rig is described in which 8×10^6 stress cycles per hour are imposed on a single ball specimen. The ball is positioned by a cage and loaded between two rotating drums. Typical test results are given. (Abstracted by H. Connors)

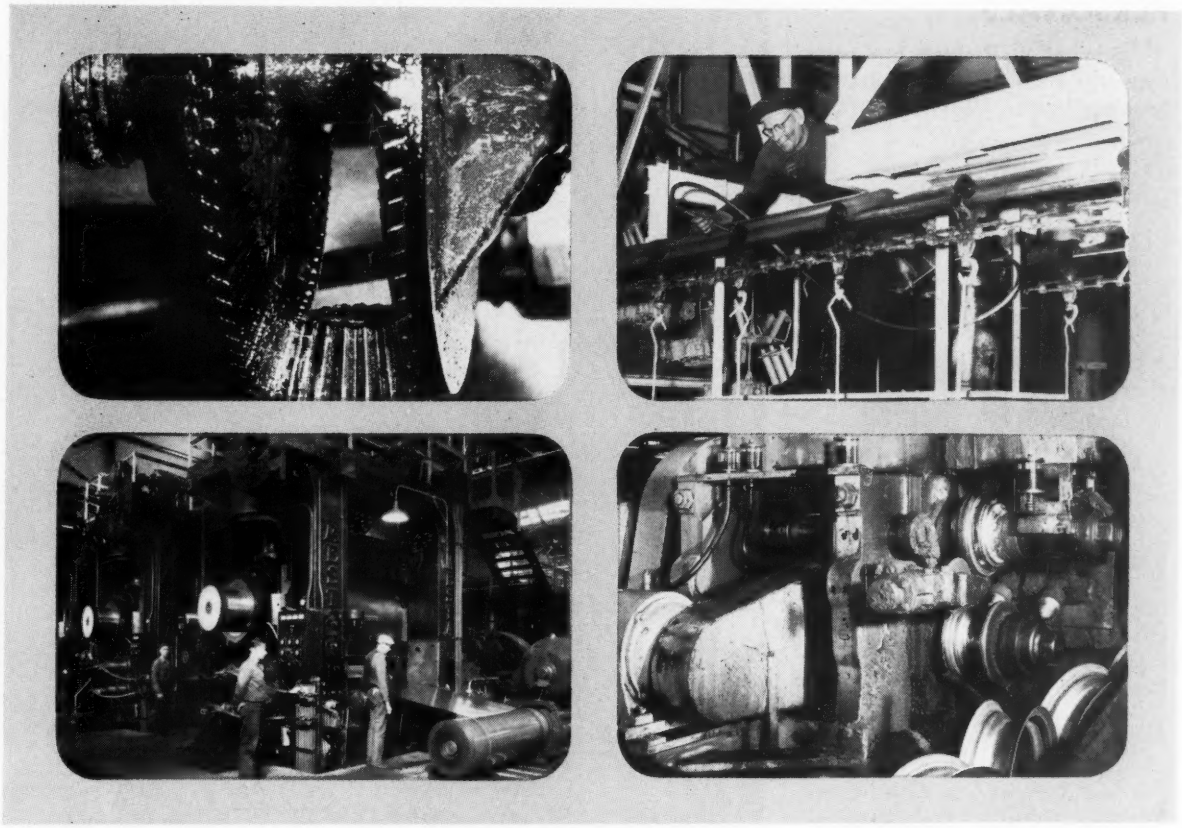
MOHLER, J. B., "Sleeve Bearing Materials," *Machine Design, Vol. 28*, n. 9, May 3, 1956, p. 105-107.

Several types of bearing materials and their applications are presented in tabular form. The speed-load and temperature-load characteristics of several bearing metals are discussed and tabulated to aid in the practical selection of a bearing material for specific design requirements. (Abstracted by H. N. Kaufman)

FOGG, A., WEBBER, J. S., "The Influence of Some Design Factors on the Characteristics of Ball-bearings and Roller-bearings at High Speeds, *Proceedings of Inst. of Mech. Engrs.*, n. 36, *Vol. 169*, 1955.

Investigations are described of the performance characteristics of ball-bearings and roller-bearings running under conditions similar to those encountered in gas turbines. The majority of the work is carried out on ball-bearings, suitable for shaft of 2 inches diameter, which are run under various combinations of radial load and thrust load. Modifications are made to diametral clearance and track curvature of the bearings and to the material, design, and dimensions of the cages. The effects of these on bearing performance are given and discussed. In-

Continued on p. 362



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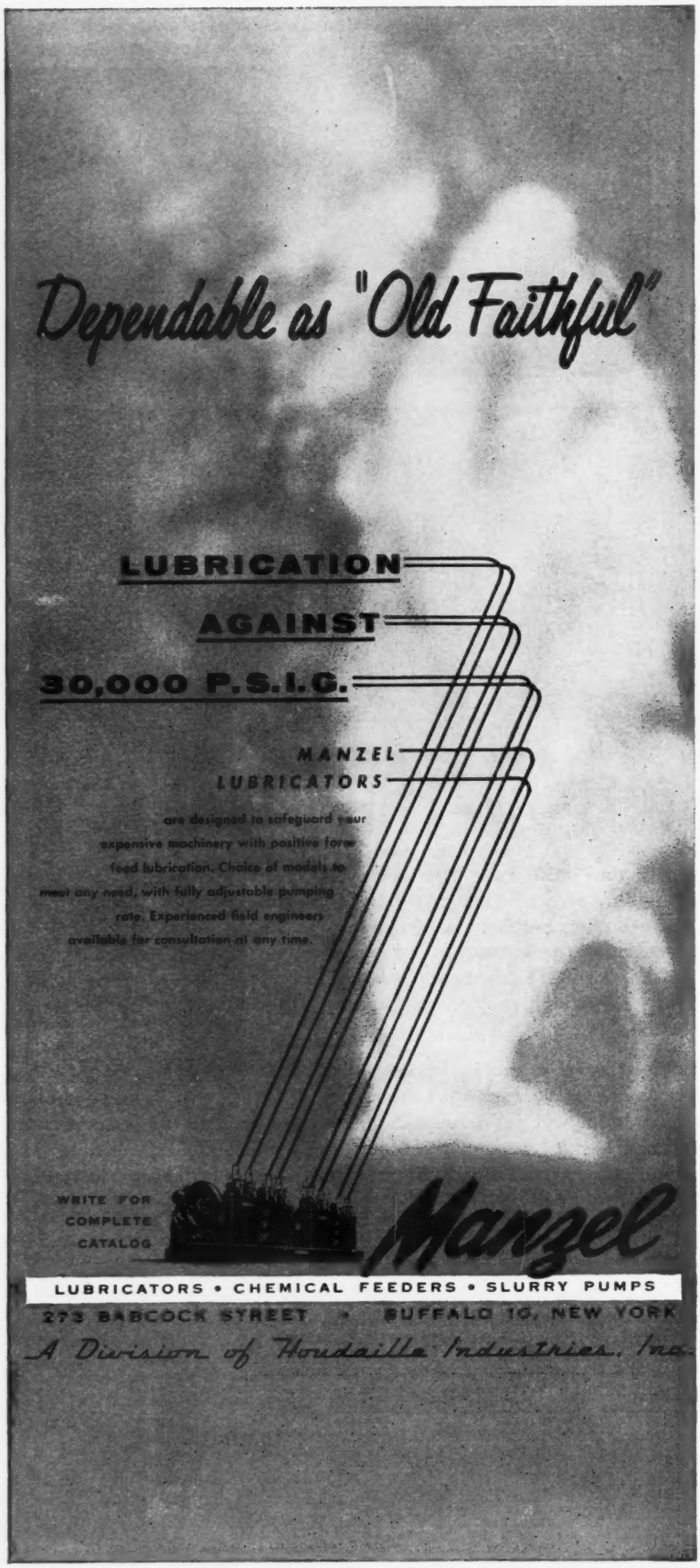
L. E. Hoyer, American Brake Shoe Co., has been appointed chairman of the Bearings and Bearing Lubrication Committee; **W. H. Craig,** The Sharpless Corp., has been appointed chairman of the Lubricant Reclamation and Disposal Committee; and **J. J. Jenkins,** Lincoln Engineering Co., has been appointed chairman of the Lubrication Equipment Committee according to an announcement by **A. A. Raimondi,** Technical Coordinator of the ASLE Joint Technical Committee.

Lube Abstracts (Cont. from p. 360)

vestigations on larger (5-inch bore) bearings indicate additional precautions to be necessary with this size. Work on roller-bearings is confined to the 2-inch size and the variables investigated include diametral clearance of bearing and end-clearance of rollers. An interesting comparison is provided by the performance of a cageless roller-bearing. (Author's Abstract)

"The Mechanics of Railway Vehicles on Curved Track" by R. S. Minchin, Jour. Australian Inst. of Engrs., July 1956, p. 179, Aug. 1956, p. 186.

Calculations are made of the forces exerted between the flanged wheels and the rails for a vehicle on a curved track using an established method of model analysis which takes into account the lateral forces exerted on the rails. Experimental tests on a model confirm the effect of friction on the equilibrium of a vehicle on a curved track deduced from the analysis, and indicate the probable nature of contact between wheel and rail. (W. E. Campbell)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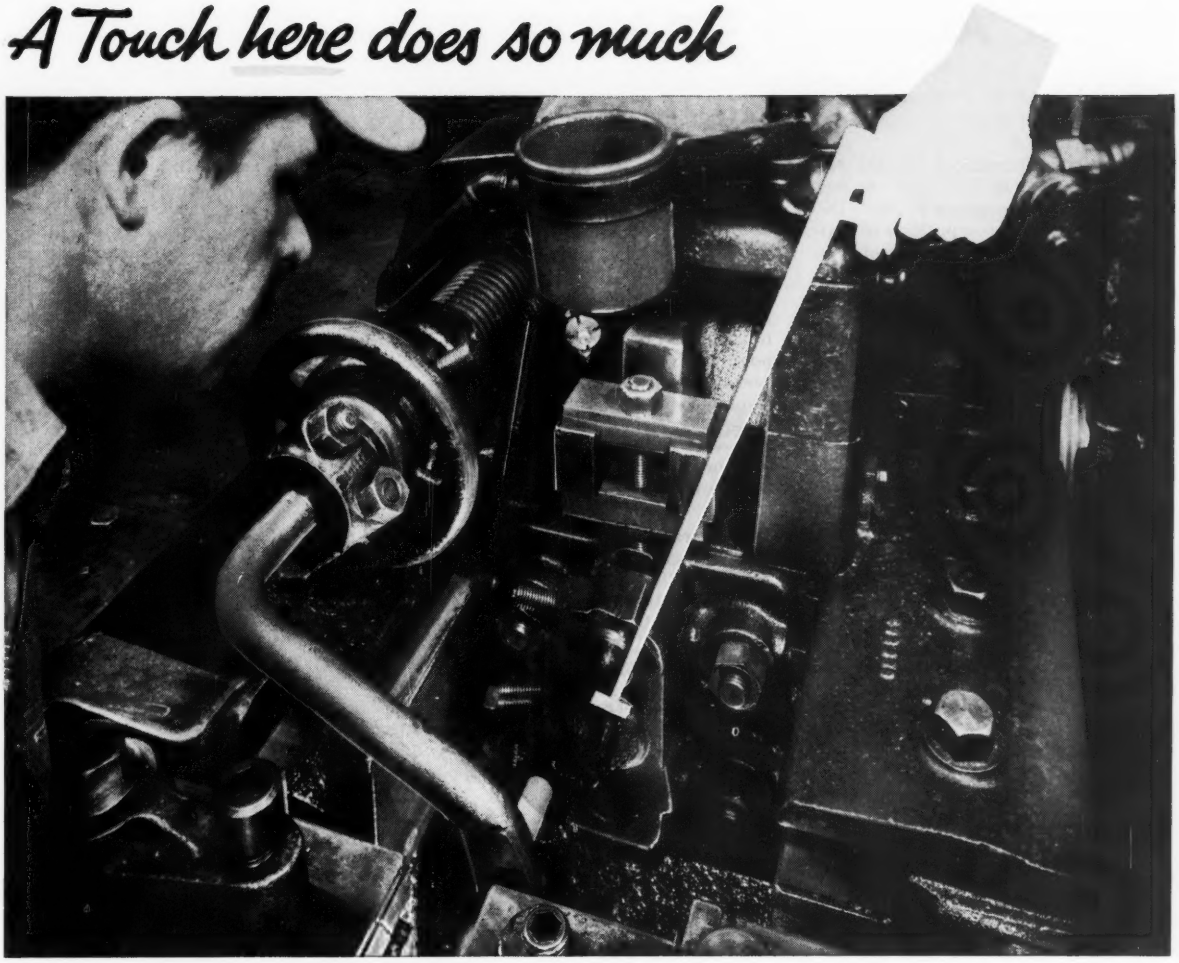

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Patent Abstracts

(Compiled by Ann Burchick, Aluminum Co. of America.)

Lubricating Compositions, Patent No. 2,765,276 (J. L. Van Winkle, E. R. Bell & R. C. Morris, assignors to Shell Development Co.) A composition of matter comprising a major amount of a lubricating oil and a minor amount, sufficient to impart extreme-pressure properties to said liquid oil.

Lubricating Oil Additives, Patent No. 2,765,277 (R. H. Jones, assignor to Esso Research & Engineering Co.) A mineral lubricating oil composition containing a detergent quantity of a product obtained by reacting about one molecular proportion of phosphorus pentasulfide with one to ten molecular proportions of a lubricating oil bright stock at a temperature in the range of about 200 to 600°F., at least substantially neutralizing the product thus obtained with guanidine carbonate and reacting the neutralized product with sufficient oxide of lead at a temperature in the range of about 250 to 500°F. to produce a product which yields an ash content in the range of about 5 to 20 weight percent.

Oil-Phase Antifreeze Inhibitor, Patent No. 2,765,278 (C. B. Holter & C. T. Anne, assignors to The Texas Co.) An antifreeze mixture adapted to be added to water consisting essentially of a polyhydroxy alcohol freezing point depressant and 0.05-2% by volume of an insoluble oil-phase inhibitor consisting essentially of a high boiling hydrocarbon oil and 0.5 to 5% by weight of 2-benzothiazyl-N, N-diethylthiocarbamyl sulfide.

Water-Resistant Lubricants Thickened with Inorganic Gelling Agents, Patent No. 2,766,205 (W. A. Marshall & C. F. Steininger, assignors to The Pure Oil Co.) A gelatinous lubricating composition comprising a major portion of an oleaginous lubricating liquid having incorporated therein an inorganic gel as a gelling agent in an amount sufficient to produce a gelatinous composition of grease-like consistency and a sufficient amount of water proofing agent for said gelling agent selected from the group consisting of quinoline, and lower alkyl substituted quinoline having not more than about eight carbon atoms in a substituent group to impart water-resistance to said composition.

Process of Treating Lubricating Oil Stock with a Phosphorus Sulfide & a Base and the Resulting Products, Patent No. 2,766,206 (H. E. Alford & J. D. Bartleson, assignors to The Standard Oil Co.) A method of processing lubricating oil which comprises treating said stock with an amount of phosphorus sulfide within the range from about 0.1 to about 0.75% while blowing an inert gas through the reaction mixture at a temperature within the range of at least 275 to about 450°F. at which the lubricating oil stock and the phosphorus sulfide react.

Hydrocarbon Oil Products, Patent No. 2,766,207 (J. P. McDermott, assignor to Esso Research & Engineering Co.) A lubricating oil composition comprising a major proportion of a mineral lubricating oil and a minor, oxidation-inhibiting amount of a product obtained by reacting about 2 moles of an alkyl phenol sulfide.

Additive-Containing Mineral Oil Compositions, Patent No. 2,766,208 (J. J. McBride, Jr., assignor to Tidewater Oil Co.) A liquid composition consisting essentially of a mineral oil of lubricating grade in major amount based upon the weight of the composition and having dissolved therein an oil-soluble addition product.

Clay-Thickened Lubricants Having Water-Resistant Characteristics, Patent No. 2,766,209 (W. A. Marshall & C. F. Steininger, assignors to The Pure Oil Co.) A gelatinous composition having lubricating characteristics which comprises a major portion of an oleaginous lubricating fluid having incorporated therein an oleophilic and hydrophobic modified bentonitic clay in an amount sufficient to impart a grease-like consistency to said composition, said clay being modified before being incorporated into said lubricating fluid by (1) treating said clay to remove substantially all of the bound water naturally occurring therein without affecting the structural water content of said clay, and (2) replacing the bound water naturally occurring in a bentonitic clay with a treating agent selected from the group consisting of monomeric diols

Continued on p. 366

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_____(56LC-7) *Application of Reaction Rate Theory to the Weld Junction Aspect of Kinetic Friction Between Unlubricated Metallic Surfaces,* by F. F. Ling & E. Saible

_____(56LC-1) *Application Problems with Petroleum Lubricants in Nuclear Power Plants,* by R. F. Hausman & E. R. Booser

_____(56LC-5) *Effects of Nuclear Radiation on Lubricants,* by J. A. King & W. L. R. Rice

_____(56LC-9) *Fretting of Hardened Steel in Oil,* by J. R. McDowell

_____(56LC-6) *Fundamental Study of Synthetic Sapphire as a Bearing Material, A,* by L. F. Coffin, Jr.

_____(56LC-2) *General Radiation Damage Problems for Lubricant & Bearing-Type Materials,* by V. P. Calkins & C. G. Collins

_____(56LC-18) *Influence of Temperature on Boundary Lubrication,* by C. W. Cowley, D. J. Ultee & C. W. West

_____(56LC-13) *Investigation of "Melt Lubrication,"* by B. Sternlicht & H. Apkarian

_____(56LC-10) *PbO & Other Metal Oxides as Solid Lubricants for Temperatures to 1000° F.,* by M. B. Peterson & R. L. Johnson

_____(56LC-4) *Radiation-Resistant Greases,* by J. G. Carroll, R. O. Bolt & B. W. Hotten

_____(56LC-8) *Solid Film Lubricant—Factors Influencing Their Mechanism of Friction & Wear,* by R. E. Crump

_____(56LC-12) *Solution for the Finite Journal Bearing & Its Application to Analysis & Design — II, A,* by A. A. Raimondi & J. Boyd

_____(56LC-16) *Specific Heat at Low Temperatures and Latent Heat of Fusion of Aircraft Engine Lubricants,* by V. E. Shrock & R. E. Gott

_____(56LC-11) *Temperature Effects in Journal Bearing Lubrication,* by W. F. Hughes & J. F. Osterle

_____(56LC-17) *Thermal Conductivity & Thermal Diffusivity of Aircraft Engine Lubricants at Low Temperatures,* by V. E. Schrock & E. S. Starkman

_____(56LC-3) *Use of Rolling Contact Bearings in Low Viscosity Liquid Metal Lubricants,* by W. Markert, Jr. & K. M. Ferguson

_____(56LC-14) *Yield Stress as a Factor in the Performance of Greases,* by D. Evans, J. F. Hutton & J. B. Matthews

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Patent Abstracts

Continued from page 364

having not more than about 10 carbon atoms per molecule C_1-C_5 ether derivatives of said diols, polymeric diols and ether derivatives thereof said diols and their ether derivatives having molecular weights of not more than about 800-1000.

Translucency of Lubricating Oils, Patent No. 2,767,122 (I. E. Puddington, A. F. Sirianni & J. R. Farnand, assignors to National Research Council) A method for improving a lubricating oil comprising treating the oil with an oxidizing agent in the presence of sodium metal.

Production of Oxidation-Resistant Lubricating Oils, Patent No. 2,767,131 (J. L. Jezl & A. Schneider, assignors to Sun Oil Co.) A method of producing a highly stable lubricating oil which comprises separating by adsorption on a solid adsorbent a lubricating oil into (A) a fraction consisting predominantly of saturated hydrocarbons, (B) a fraction consisting predominantly of mononuclear aromatic hydrocarbons, and (C) a fraction consisting predominantly of polynuclear aromatic hydrocarbons, hydrogenating fraction (B) to produce a fraction (D) consisting predominantly of saturated hydrocarbons, and blending fractions (A), (C) and (D) in a ratio of saturated hydrocarbons to polynuclear aromatic hydrocarbons of from about 95:5 to 50:50 to produce a highly stable lubricating oil.

Lubricating Compositions, Patent No. 2,767,142 (R. C. Morris, J. L. Van Winkle & P. H. Williams, assignors to Shell Development Co.) A composition of matter consisting essentially of a major amount of lubricating oil and a minor amount, sufficient to stabilize against oxidation deterioration and impart extreme-pressure properties to said liquid vehicle, of a middle halophosphorus compound.

Lubricating Compositions Containing Metal Derivatives of 1,3-Bis(Hydroxy-Aralkyl)-2-Imidazolidinethiones, Patent No. 2,767,143 (J. M. Caffrey, Jr., H. D. Kluge & J. E. Tessieri, assignors to The Texas Co.) A lubricating composition comprising a mineral lubricating oil containing about 0.1 to about 5.0 percent by weight of a metal derivative of the reaction product at an elevated temperature of carbon disulfide with a condensation product of one mol equivalent of a hydroxyaromatic compound with about one mol equivalent of an aldehyde and at least about one-half mol equivalent of an amine compound containing two primary amine groups separated by two carbon atoms, said metal derivative having the hydroxyl hydrogens of the said reaction product replaced by a member of the group consisting of metals, metal hydroxides, and metal alkoxides containing from 1 to 5 carbon atoms.

Stabilized Organic Sulfur-Containing Compounds, Patent No. 2,767,163 (T. J. Peters, Jr., assignor to Esso Research & Engineering Co.) In a method for preparing organic sulfur-containing compounds useful as lubricating oil additives and selected from the group consisting of sulfurized hydrocarbons and phospho-sulfurized metal salts of alkyl phenol sulfides, the improvement in accordance with which the odor of said organic sulfur-containing compounds is improved which consists essentially of contacting said organic sulfur-containing compounds selected from the group consisting of sulfurized hydrocarbons and phospho-sulfurized metal salts of alkyl phenol sulfides with a vaporous oxide of nitrogen at a temperature of about 50 to 250° F. for about 5 minutes to 1 hour to thereby substantially reduce the evolution of hydrogen sulfide from said organic sulfur-containing compound without removing substantially any sulfur therefrom, said contacting being carried out in the substantial absence of water and employing about 3 to 100 cubic feet of vaporous oxide of nitrogen per hour per gallon of said organic sulfur-containing compound.

Addition Agents, Patent No. 2,767,165 (H. G. Smith & T. L. Cantrell, assignors to Gulf Oil Corp.) An addition agent for mineral oil lubricants comprising a salt selected from the group consisting of alkaline earth metal salts and primary aliphatic amine salts, said primary aliphatic amine having from 8 to 22 carbon atoms, of a product prepared by heating an essentially paraffinic base lubricating oil with anhydrous aluminum chloride at a temperature of from 150 to 350° F., removing aluminum chloride from the reaction product, and reacting the latter with phosphorus pentasulfide at a temperature of from 450° F. to a maximum temperature below the minimum cracking temperature of said reaction product to incorporate phosphorus and sulfur therein.

Continued on p. 367

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Distilling a Lubricating Oil with an Aldehyde & a Solid Reagent to Produce Color-Stable Lubricating Oil Fractions, Patent No. 2,768,122 (C. E. Wilson, assignor to Union Oil Co. of Calif.) A method of producing relatively color-stable hydrocarbon fractions boiling in the lubricating oil boiling range which comprises distilling a hydrocarbon oil containing hydrocarbons boiling in said range in the presence of relatively small amounts of an aldehyde substance selected from the class consisting of formaldehyde, acetaldehyde, propionaldehyde, furfuraldehyde and formaldehyde genitors and an auxiliary agent selected from the class consisting of the alkali and alkaline earth metal hydroxides and active clay.

Oxidation-Resistant Mineral Oils & Method of Preparing Same, Patent No. 2,768,129 (W. T. Knox, Jr., assignor to

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Esso Research & Engineering Co.) An improved lubricating oil composition comprising a mineral lubricating oil containing an oxidation-inhibiting amount of a relatively narrow fraction of a silica gel aromatic extract obtained from a paraffinic-base mineral oil base stock, said fraction being selected from the last 30% of the aromatics most strongly adsorbed by the silica gel and having a spread of less than 10% of the total aromatic extract.

Complex Basic Aluminum Soap Greases, Patent No. 2,768,138 (B. W. Hotten & R. E. Echols, assignors to California Research Corp.) A grease composition consisting essentially of a major proportion of a hydrocarbon lubricating oil and, in an amount sufficient to form a grease, a complex basic aluminum soap, said complex basic aluminum soap being an aluminum benzoate stearate wherein the benzoate anion-stearate anion ratio has a value from 0.2 to about 5.

Lubricating Greases from Oxo Glycols, Patent No. 2,768,139 (D. W. Young, A. J. Morway, & D. L. Cottle, assignors to Esso Research & Engineering Co.) A lubricating grease comprising a minor grease-making proportion of a grease thickener selected from the group consisting of the alkali metal and alkaline earth metal soaps of carboxylic acids having from 10 to 30 carbon atoms and complexes of said soaps with salts of said metals with lower molecular weight carboxylic acids and a major grease-making proportion of a lubricating oil selected from the group consisting of monoglycols having 5 to 30 carbon atoms per molecule obtained by the catalytic oxonation of an alicyclic compound having two non-conjugated olefinic linkages, one of which linkages is in a ring, with carbon monoxide and hydrogen at temperatures of about 225 to 400°F. and pressures of about 2,000 to 4,000 psig followed by catalytic hydrogenation of the oxonation product; and diesters of said monoglycols with monobasic carboxylic acids having 2 to 10 carbon atoms per molecule.

Oil-Soluble Sodium Hydrocarbyl Phenates as Color Stabilizers for Mineral Lubricating Oils, Patent No. 2-768,140 (A. J. C. Bart & B. C. Maas, assignors to Shell Development Co.) A color-stable, oxidation-resistant mineral lubricating oil composition consisting of a major amount of a mineral lubricating oil having incorporated therein from about 0.0001% to about 0.01% by weight of an oil-soluble sodium alkyl phenate, said alkyl radical having at least 8 carbon atoms.

Hydraulic Transmission Fluid, Patent No. 2,768,953 (W. C. Howell, Jr. & J. I. Wasson, assignors to Esso Research & Engineering Co.) A lubricant composition of high detergency and superior anti-friction properties, consisting essentially of a major proportion of a lubricating oil of low viscosity, 1 to 6% by weight based on the total composition of a P_2S_5 treated alkaline earth metal salt of alkyl phenol sulfide as a detergent, and 0.2 to 1% of oleic acid.

Lubricant, Patent No. 2,768,954 (E. K. Fields, assignor to Standard Oil Co.) A composition comprising a petroleum lubricating oil and from about 0.01% to about 5% of an oil-soluble material obtained by reacting in a ratio of from about 1:5 to about 10:1 parts by weight of a compound selected from the group consisting of alcohols, phenols, mercaptans, and thiophenols with an unneutralized product of a phosphorus sulfide and a polymer of a mono-olefinic hydrocarbon of less than 6 carbon atoms, which polymer has a molecular weight in the range of from about 150 to 50,000, at a temperature in the range of from about 150 to about 500°F.

Permanent Anti-Freeze Liquid Containing an Anti-Foam Phase of a Silicone in a Mineral Lubricating Oil, Patent No. 2,768,955 (T. C. Heisig, assignor to The Texas Co.) A two-phase, permanent-type anti-freeze liquid consisting essentially of a polyhydric alcohol phase containing 92-97% by weight of a polyhydric alcohol having a specific gravity greater than 1.0 as the predominating constituent and a corrosion inhibitor soluble in the polyhydric alcohol, and 0.90-1.25% by volume based on the polyhydric alcohol phase of an anti-foam phase having a specific gravity less than 1.0 consisting essentially of a mineral lubricating oil insoluble in said alcohol having a specific gravity in the range of 0.9 to 0.93 containing dispersed therein a foam inhibiting amount up to 2% by weight based on the said anti-foam phase of an organo-silicon oxide polymer having anti-foaming properties.

Lubricating Oil Additive Having Improved Copper Corrosion Properties, Patent No. 2,769,782 (J. P. Rocca & A. C. Henn, assignors to Esso Research and Engineering Co.) In the process in which an oil-soluble sulfur- and phosphorus-containing product having antioxidant properties in the presence of organic materials is formed by reacting together a metal alkyl phenol sulfide and P_2S_5 at a temperature in the range of about 100 to 200°C., the improvement for reducing the tendency of the product to corrode metals which comprises utilizing a metal phenol sulfide which contains less than about 0.3 weight percent water and a mol ratio of P_2S_5 to said metal phenol sulfide below 0.25:1.0.

Lubricating Compositions, Patent No. 2,769,783 (W. C. Hollyday, Jr., assignor to Esso Research & Engineering Co.) A lubricating oil composition which comprises a mineral lubricating oil containing from 0.005% to 60% by weight based on the total composition, of a condensation product of a polymer prepared by polymerizing a material.

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Method of Oil Testing & Composition Therefor, Patent No. 2,770,530 (R. F. Bergstrom, T. S. Hodgson & H. E. Hook, assignors to Shell Development Co.) The method for determining the suitability of a used lubricating oil for further use in an internal combustion engine which comprises placing a small quantity of said oil in a thin essentially white porous medium, pouring over said small quantity of oil a solution of an organic acid-base indicator compound which exhibits a color change in th pH range of 3 to 6 in an essentially neutral developer solution comprising essentially from about 0.5 to about 20% by volume of water, at least 15% by volume of a monohydric alcohol and from about 4 to about 70% of a water immiscible oil-solvent, the concentration of said acid-base indicator compound in said developer solution being from about 0.0001 to about 0.05 gram moles of said indicator compound per liter of said developer solution.

Soluble Oil, Patent No. 2,770,594 (J. L. Jezl, assignor to Sun Oil Co.) A soluble oil composition comprising: mineral lubricating oil; alkali metal soap of petroleum mahogany sulfonic acids; alkali metal soap of carboxylic acids obtained by partial oxidation of mineral oil; 2.25 to 5.0 volume percent of water; and 1.25 to 3.0 volume percent of a phenyl alkanol having 7 to 9 carbon atoms inclusive; said soluble oil having sulfonate saponification number equivalent within the range from 3 to 10 mg. of KOH per gram and carboxylate saponification number equivalent within the range from 10 to 20 mg. of KOH per gram.

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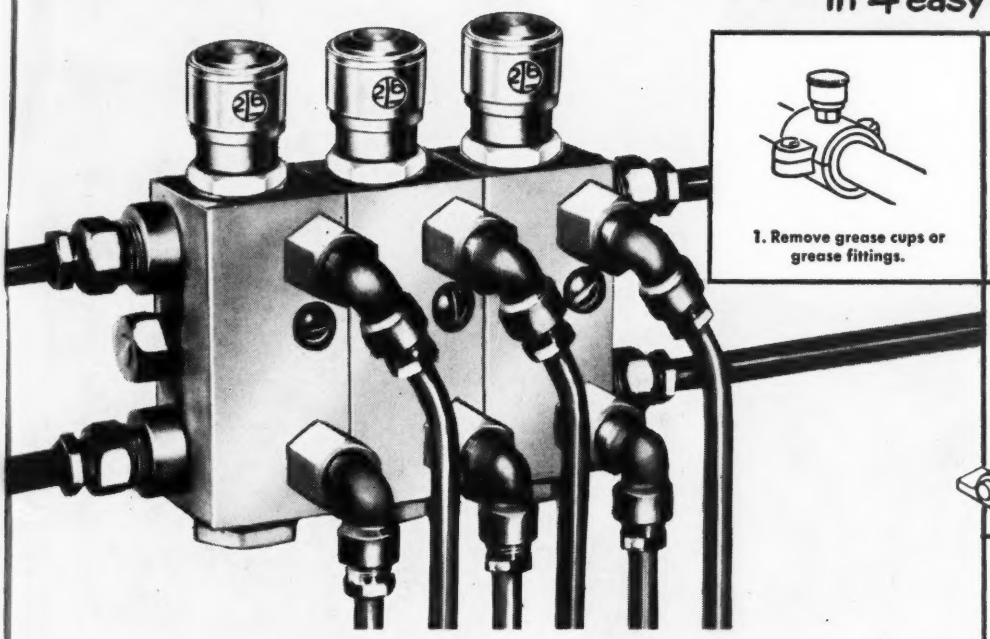
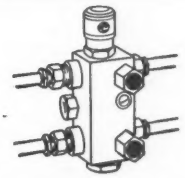
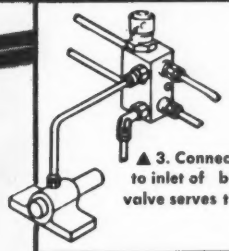


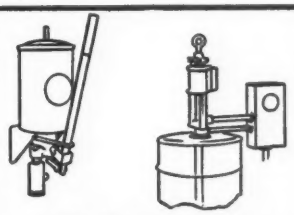
1. Remove grease cups or grease fittings.



2. Connect each valve in system to its two lubricant supply lines.



▲ 3. Connect valve outlets to inlet of bearings. (Each valve serves two bearings.)



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